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ELLIOT R. DOWNING

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BOLD HEADLANDS ON LAKE SUPERIOR

A NATURALIST IN THE GREAT LAKES REGION

By

ELLIOT ROWLAND DOWNING
The School of Education, University of Chicago

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GENERAL PREFACE

Never before in this country has there been so insistent a demand for a more thorough and more comprehensive system of instruction in practical science. Forced by recent events to compare our education with that of other nations, we have suddenly become aware of our negligence in this matter. Now industrial and educational experts and commissions are united in demanding a change.

While on the whole there has been a steady increase in the amount of time given to science work in the secondary and elementary schools, the attention paid to it, especially in the elementary schools, has been somewhat spasmodic, and its administration has been more or less chaotic. This is not due to lack of interest on the part of school officials but to their dissatisfaction with the methods of instruction employed. There is no doubt that superintendents would gladly introduce more science if they felt sure that the educational results would be commensurate with the time expended. This is indicated by a recent survey of about one hundred and fifty cities in seven states of the Central West. The survey shows that two-thirds of them have nature-study in the elementary schools and that all are requiring some science for graduation from the high school. The average high school is offering three years of science. Since 1900 there has been a greater increase in the percentage of students enrolled in science in the high schools than in any other subject with the one exception of English. Moreover, greater attention is now being paid to the training of teachers in methods of presentation of science.

The chief needs in science instruction today are a more efficient organization of the course of study with a view to its socialization and practical application, and a clear-cut realization on the part of the teacher of the aims, the principles of organization, and the methods of instruction; it is to meet these needs that this series is being issued. The books attempt to present such generalizations of science as the average pupil should carry away from his school experience and to organize them for the preparation of the teacher and for presentation to the class. The volumes will therefore be of three kinds: (1) source books with accompanying field and laboratory guides for the use of students in normal schools and schools of education, and of teachers, (2) pupils' texts and notebooks, and (3) books on the teaching of the various science subjects. In the first the material will be organized with special reference to the training of the teacher and the most effective methods of presenting the subject to students. In the second the matter will be simplified, graded, and arranged in such a way that the books will serve as guides in science work for the pupils themselves. Moreover, they will furnish texts for the grades and high school that will simplify the teacher's task of presentation and will assure well-tried and well-organized experiences, on the part of the pupil, with natural objects. This series of texts for elementary and secondary schools will have dependent continuity and the subject-matter will gradually increase in difficulty to accord with the increasing capacity of the pupils. It will furnish a unified course in science. The third type of book is for the teacher and deals with the history, aims, principles of organization, and methods of instruction in the several sciences.

AUTHOR'S PREFACE

There is no commonplace; the most dully monotonous environment is full of wonders, if vision can be enlarged to apprehend them. J. Henri Fabre, that astute French naturalist whose portrayal of the interesting lives of the humble denizens of field and forest we are all reading with avidity, saw more of the marvelous in his own back yard than the average globe-trotter sees in all his travels. Slabsides was but a poor shack in an ordinary farm wood lot. The pond at Walden has its duplicate in the outskirts of a thousand American villages. But John Burroughs and Henry D. Thoreau had eyes to see, ears to hear, and hearts to understand.

Fortunately there is an ever-increasing number of persons, both young and old, who are learning what fascination there is in the tales Nature spreads before our eyes in hill and dale, river and forest, bird and beast, flower and blade of grass. They are learning to read the landscape, to achieve a companionship in the outdoors quite as real and as satisfying as that of a wise friend or a stimulating book. For such this book is written as an aid to an understanding of familiar surroundings.

It is hoped the volume may serve as an advanced general science, particularly for those teachers who believe that science instruction at its best is an attempt to interpret the significance of the commonplace. It craves audience, too, of all those nature-lovers who desire an introduction to the study of the things about them as one means of culture. The several type regions are treated in separate chapters so that one may take it as a companion into the Dunes, the forest, the prairie, the river valley and learn by means of the brief descriptions and illustrations to identify the plants, animals, and physiographic processes encountered, and appreciate something of their meaning.

The author is indebted to Miss Helen Snyder for the care with which many of the drawings have been made. While the drawings, except as acknowledged in the text, have been made from the specimens, suggestions as to methods of expressing essential characters have been taken at times from the books mentioned in the list at the end of the volume. The author gratefully acknowledges his indebtedness.

A few of the half-tone illustrations are from negatives in the collection of the School of Education, for the use of which the author expresses his indebtedness.

ELLIOT R. DOWNING

UNIVERSITY OF CHICAGO
SCHOOL OF EDUCATION
December 27, 1921

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CHAPTER I

THE CHANGING FACE OF NATURE

CHICAGO is the center of a region of quiet but varied beauty. He who limits his excursions to the city parks or the immediate vicinity of the city sees only a monotonously level plain, but to him who wanders along the North Shore, explores the Dunes, or rambles over the wooded hills of the nearby moraine country there are presented bits of landscape that charm even the casual observer with their wealth of form and color. The encircling horizon line shrouded in the shimmering haze of the lake or broken by the billowy hills, the nearby woodlands, the cloud shadows that play among them, the cleared land checkered by its varied harvests or dotted with grazing cattle, the brook playing hide and seek among the tangled shrubs and ferns, the bird song whistled from the bough tip—all are sources of exquisite pleasure. Poet and painter fairly astound us with the revelation of beauty which they, with fine sensitiveness, perceive in even so commonplace an outlook. Science too is a revealer. It adds a third dimension to the landscape; it gives depth. It delves below the surface to the foundation. It gives the perspective of time. To the thoughtful man the outstretched view is not alone a beautiful prospect; it is a voice from the past and speaks of history as eventful as do the care-wrought furrows of the human face.

Many agencies of land formation, disintegration, and alteration have been at work in times past to produce the present features of this region, and most of them are still at work changing its appearance slowly but surely. Go out along the shore

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where high clay bluffs stand at the water's edge, as at Fort Sheridan or Lakeside, and see, during a storm, the pounding waves gnawing at their bases. As they are undermined the unsupported upper portions slide down, carrying the vegetation, even the trees, the soil, and contained bowlders into the insatiable maw of the lake (Fig. 1), all to be ground up by the wave action and deposited in time out in quiet water as beds of sand or clay, or transported and thrown up on shore in sandy or muddy beaches. This process of wave erosion and deposition goes on ceaselessly and has been going on for ages, not only on the shores of Lake Michigan, but wherever land masses are exposed to the attacks of the waves. Serried ranks of billows (Fig. 2) armed with rock fragments hurl themselves in relentless fury on the slow-retreating land. The softer portions of the shores, even the rock-bound shores, in the age-long battle are worn away rapidly and form deep bays. The more resistant sections stand

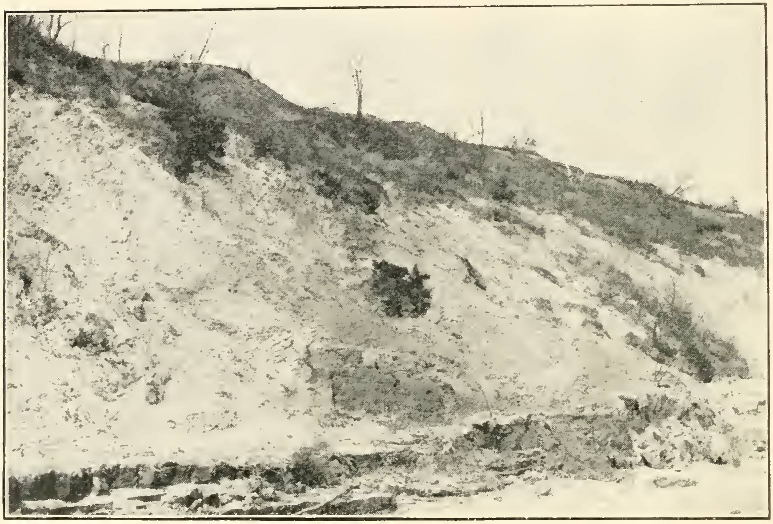


FIG. 1.—Clay bluffs near Winnetka on shore of Lake Michigan, showing erosion. The base is torn up by waves and the whole unsupported side is moving down, as shown by shrubs and trees in various stages of transit from top to bottom.

out as bold headlands, only in time to also yield to the continuous charges (Frontispiece). When it is realized that this battle-line of sea and land is 175,000 miles long and that in a storm the waves strike with the force of several tons per square foot and bombard the shore with rock fragments that weigh up to a ton, it is evident that the oceans and the great lakes have been and still are mighty agents of erosion, in time destroying even the most resistant land masses.

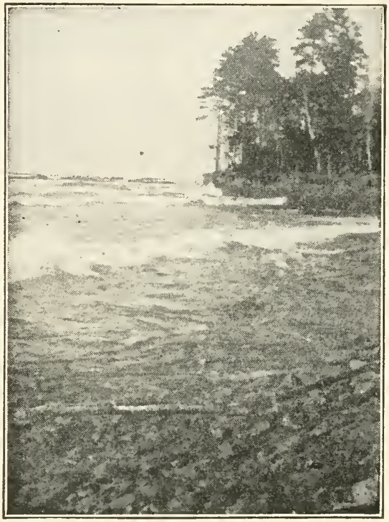


FIG. 2.—Ranks of billows

Running water in rivulets, creeks, and rivers is another powerful agent of land erosion. Follow any stream and you will not have traveled far before you will find some place where it is cutting its banks (Fig. 3). Thorn Creek, near Glenwood, Salt Creek, one-half mile upstream from Brookfield, the Desplaines at Lockport, and Fraction Run, above Delwood Park, give excellent demonstrations of the cutting power of a stream. In newly upheaved sections, like mountain areas, the streams are torrents (Fig. 4) that wear down their narrow valleys, cutting deeply and rapidly, both by virtue of their terrific force and by the angular rock fragments they carry that act as graving tools. When the stream has cut down to somewhere near the level of the body of water into which it flows, it runs more slowly, meanders back and forth across its valley, attacking and undermining the bounding hills, thus gradually widening its influence. Then its valley changes from the deep and narrow canyon of a young stream to the broader basin of an old river (Fig. 448). A river valley, then, is largely the work of the stream it contains. The whole valley, limiting hills, meanders, flood plain, cuttings, and fills, may be seen in perfection in many of the smaller streams, such as Salt Creek near Brookfield, Thorn Creek near Thornton, Pettibone Creek at North Chicago.

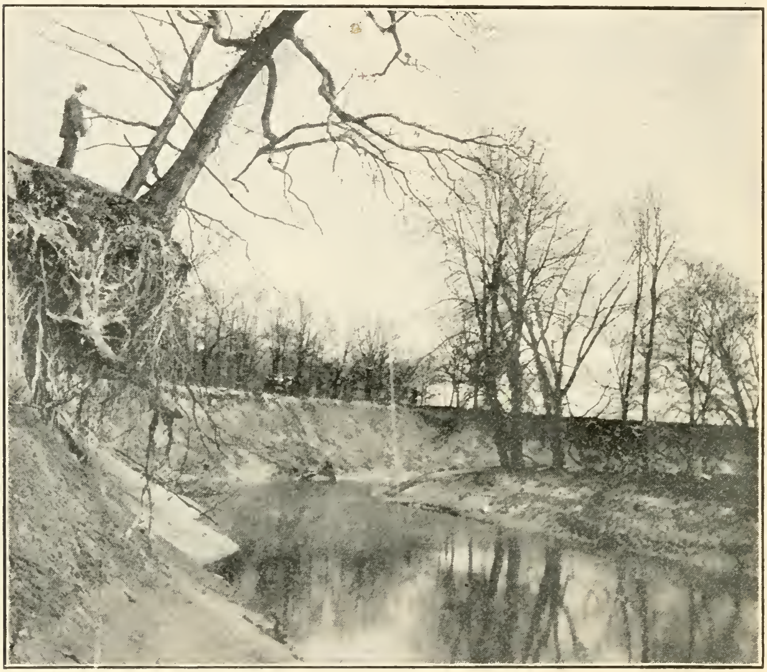


FIG. 3.—A stream cutting its banks. Photo by Fuller

The Chicago region shows many stages in the formation of the valley. Where the lake shore is high, as it is from Glencoe northward or on the eastern shore from New Buffalo north, the melting snows and spring rains find their way to the shore along irregular depressions, then plunge down the steep bank in headlong turmoil, cutting rapidly a steep-sided ravine. Gradually the stream eats its way back toward the relatively level meadowland. You may follow down its course from where the

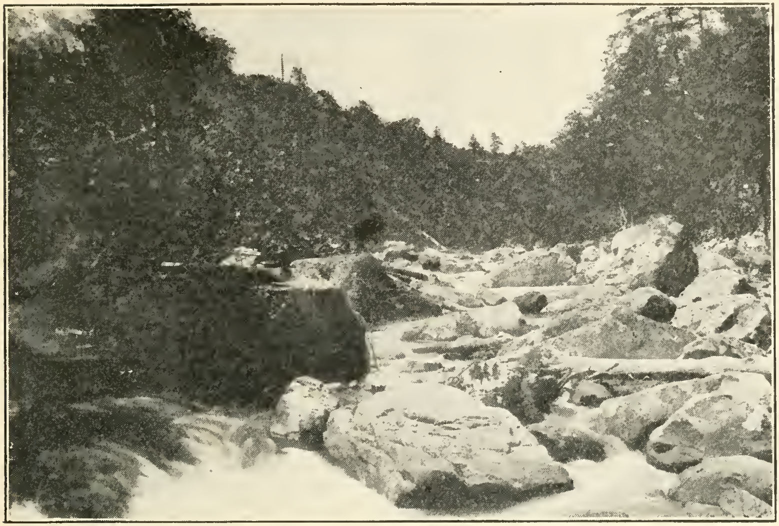


FIG. 4.—A mountain torrent. Note the valley is steep-sided

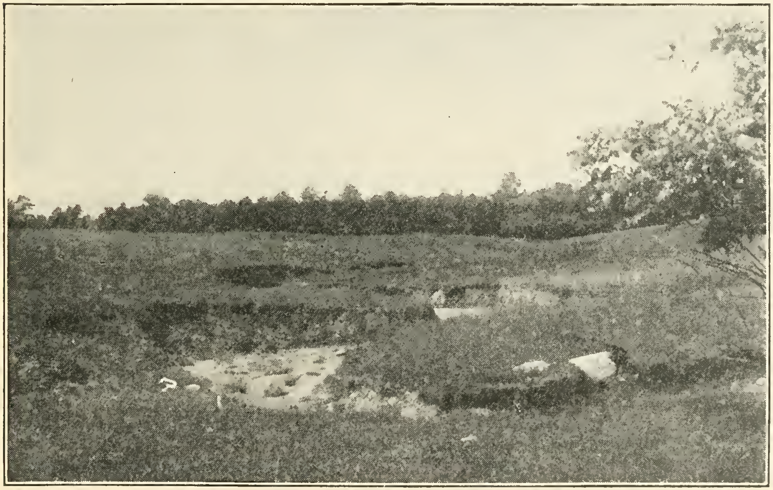


FIG. 5.—The beginnings of a ravine

little runnel is starting out from some grassy depression (Fig. 5), pass the fairly level upper stretches where it meanders, cutting an irregular course as it grows by minor tributaries, enter the V-shaped valley (Fig. 6) in which it is flowing with irresistible vigor straight for its goal—a valley that deepens and widens with every advance—and finally arrive where for a few rods it may proceed a placid little river just before it enters the lake.

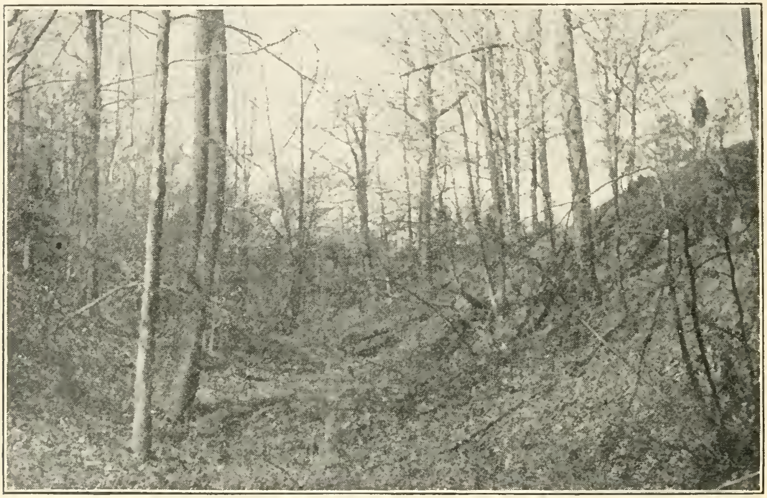


FIG. 6.—A later stage, the deep V-shaped ravine

Valleys which exemplify similar stages of development are seen where the stream cuts its way down through the rock, only in this case the valley sides are likely to be very precipitous if the cutting is at all recent, since it takes much longer for the forces of erosion to crumble down the valley sides. No better illustration of such valleys cut out of the rock can be found than those exhibited in the neighborhood of Starved Rock on the Illinois River, Oregon on the Rock River, and the Dalles of the Wisconsin (Fig. 7), all beauty spots easily accessible from Chicago. Standing on the top of Starved Rock, the valley lies spread out before your eye, bounded on either side by

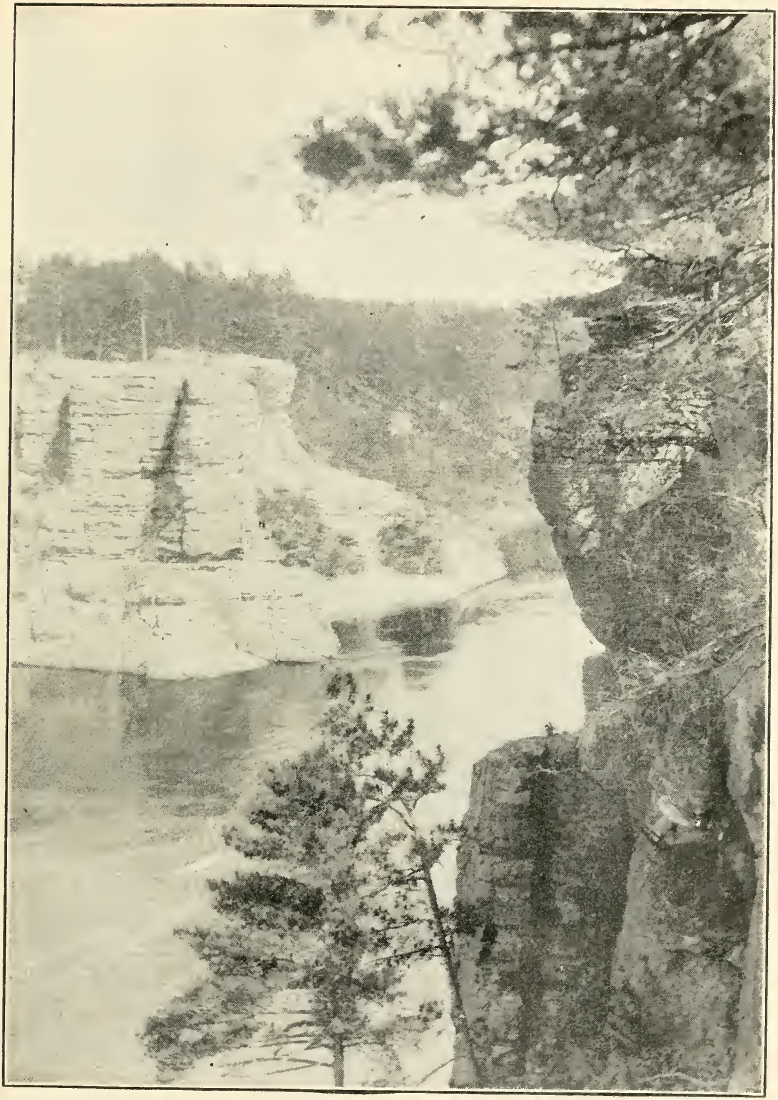


FIG. 7.—The Dalles of the Wisconsin. The trees on the rocks at right are white pines, *Pinus strobus*. The rock is St. Peter's sandstone.

precipitous hills (Fig. 8). The rock of the region is a rather soft sandstone and the river has cut its way deeply into this, scouring out its valley as it shifts from side to side in its meandering way. The surrounding country is slightly rolling farm land, giving the impression of a level plain. It is startling to walk or drive across this country and then suddenly find yourself on the brink of a deep valley with precipitous sides, 100 feet sheer, and look across to the opposite side, 3 or 4 miles away. The tributary streams flowing to the river from the plain plunge down in foaming falls which eat their way back through the sandstone, forming narrow chasms that end abruptly at their head in a rock wall down which, when the stream is full, the water thunders (Fig. 9).

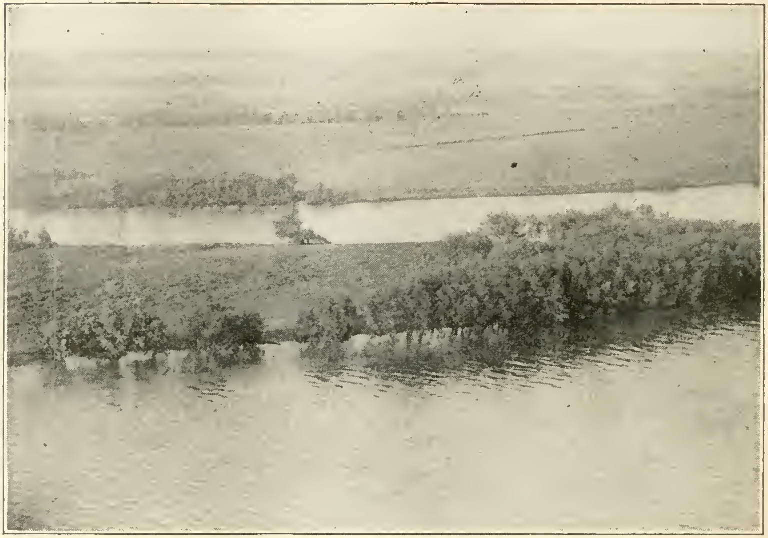


Fig. 8.—The Valley of the Illinois River, looking from Starved Rock to the bluffs on the opposite side.

There is a small but very interesting rock canyon cut in the limestone on the south side of the valley of the "Calumet Feeder" 1 mile east of "Sag" Station on the Chicago & Joliet Interurban (Fig. 393). Fraction Run cuts through the limestone

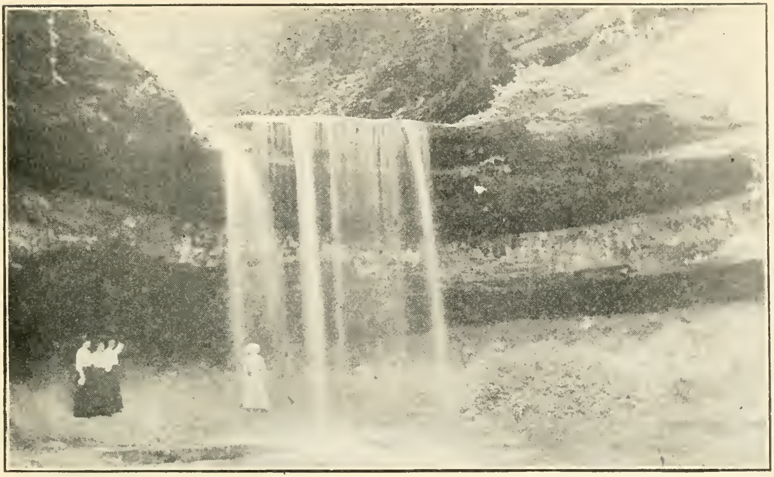


FIG. 9.—A narrow rock ravine ending in a waterfall. Deer Park Canyon near Starved Rock. Photo by O. W. Caldwell.

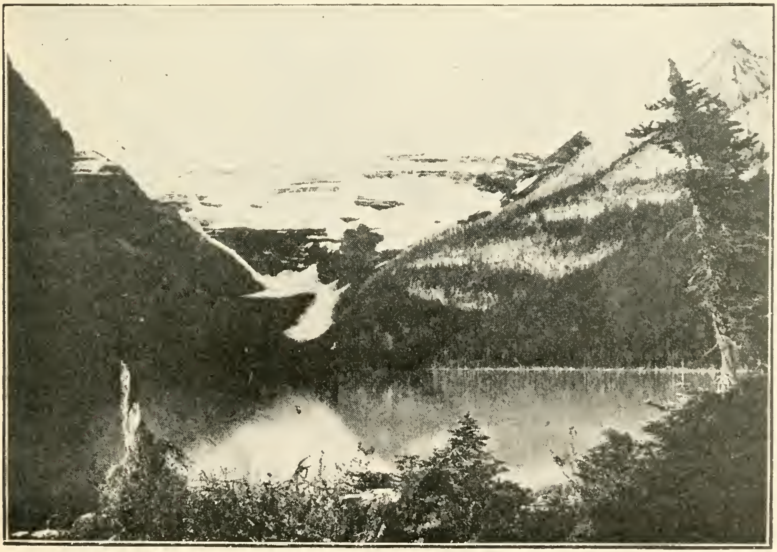


FIG. 10.—In the Canadian Rockies, a glacier made by the confluence of several smaller glaciers emanating from the snow fields on the mountains in the background.

and makes some short canyons near Joliet, one of which is included in Delwood Park. Sugar Creek has cut a gorge nearly fifteen feet deep in the suburbs of Joliet, crossed by the Chicago & Alton main-line tracks going south.

Water may be quite as efficient an agent of land destruction when running underground as it is when on the surface, particularly in limestone regions. Percolating through soil filled more or less with disintegrating organic matter that liberates CO_2 the water becomes charged with this gas. In such a condition its power to dissolve limestone is relatively great. Following some crevice, joint, or bedding-plane, the water excavates the rock, carries it away in solution, and underground caverns are formed, at times of great extent and wonderful beauty. While none are to be found in the immediate Chicago region except small ones discovered as the limestone is quarried, yet we are near enough

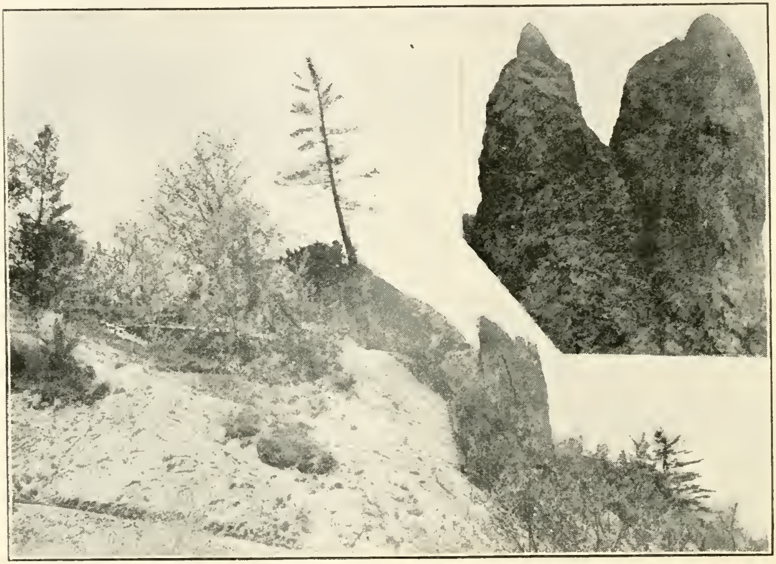


FIG. 11.—Clay pinnacles, erosion remnants, near Lakeside, Mich. Note white pine, *Pinus strobus*, and juniper, *Juniperus communis*, on crest. Inset, details of other nearby pinnacles.

to the caverns of southern Indiana and of Kentucky so that their fame is familiar.

In frigid regions the rivers, which in our latitude rise in lakes and pursue their lively way down the outletting valleys, may be replaced by streams of ice (Fig. 10) which take their origin in the great snow fields of the mountain basins and plow their way down the valleys slowly but with irresistible force. The loose soil is pushed before them; the solid rock is worn away by the terrific grinding force of the ice, hundreds of feet deep, holding in its grip the fragments of rock that abrade like giant's sandpaper in the hands of Hercules. Once upon a time, as will be detailed later, the Chicago region was covered by the glacial ice cap that overspread nearly all of northern North America. The surface of the bed rock here is planed off, covered with scratches and parallel grooves made by the moving ice sheet (see Fig. 41), and the earth that overlays the rock is full of bowlders of granite, greenstone, diorite, and other foreign rock transported from the ledges far to our north, worn smooth and scored with striations in their progress (see Fig. 40).

The pelting rain is no insignificant agent of erosion. Each drop seems a puny thing, but multiply them endlessly and let them act age after age and they do wear away the land. The wash on steep hillsides is very apparent. The water runnels during the heavy rains cut steep-sided valleys, between which there stand up sharp-edged clay ridges and pinnacles (Fig. 11). These serve to call attention strikingly to an agency that works so unobstrusively it might easily go without notice. Such pinnacles in clay, the result of rains and spring freshets, are seen along the lake shore as, for instance, near Lakeside where the clay moraine comes to the lake. In a similar way the rock itself is worn away by the pelting rain, and pinnacles are left standing mute testimony of the former height of all the land, now largely gone through erosion.

The heave of water in the rock crevices when it transforms to ice is another destructive action of water. Man realizes its might when it fragments the cement sidewalk or tears the plaster from the exterior of a house. But it is quite as powerful when it operates on the rock of a cliff or the disintegrating bowlder. At the base of a rock cliff is often found a pile of rock débris, the talus, the accumulation of the incessant disintegration of the rock above (Fig. 12).

The moisture-laden atmosphere is always busy producing destructive changes on the exposed rocks. Crack open any field bowlder and you will see a layer of weathered material on its outer portion that crumbles readily. The rock piles, excavated in mining or quarrying, show nicely the results of this weathering. The great angular blocks that were dumped a decade or more ago are crumbling into heaps of rock fragments, many of them sufficiently disintegrated to make coarse soil where weeds and some trees are beginning to root. This process of the transformation of blocks of rock into soil may readily be seen on the dumps of the local quarries or along the line of the

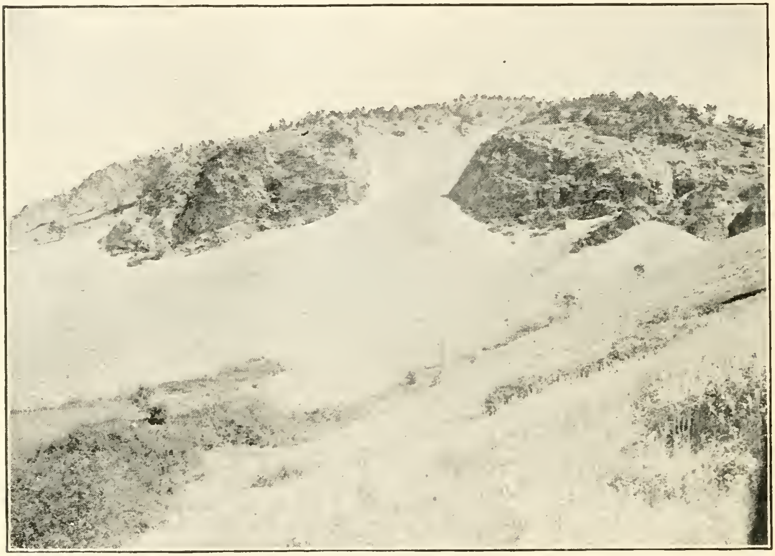


FIG. 12.—A talus at foot of cliff and outwash from the hills

Chicago Drainage Canal, conveniently reached at Willow Springs, or on the rock dumps of the coal mines near Braiderwood, on the Chicago & Alton Railroad.

Wind must be regarded as an agent of land destruction, and a transformer of the landscape. One needs only spend a day in the Dunes to realize its efficiency, if that day be a windy one. There is visible evidence that the wind is moving the sand; the air is full of it. Close to the ground it is drifting along and strikes one's hand or face, when lying down, with stinging force. The hills of sand are moving inland (Fig. 13) covering up the forests, invading the streams, and turning them from their courses. The movement of the great dunes, hills of sand hundreds of feet high and thousands of feet long that sweep along like snow drifts, is quite rapid. The steep front may advance several feet a year, by actual measurement from stakes

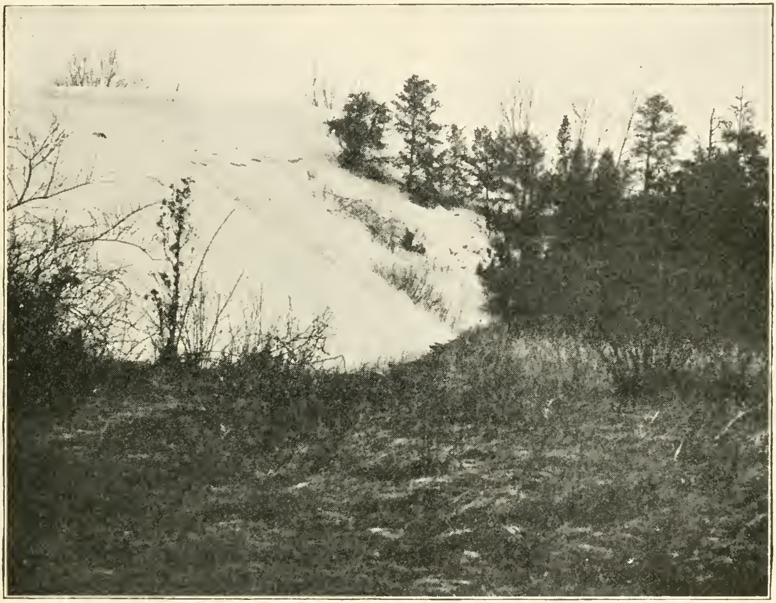


FIG. 13.—A moving dune invading a swamp and burying pines and junipers on its margin.

set at regular intervals to serve as fixed standards. Forests are covered, killed, and uncovered.

When on the old dunes, covered now with woods, a great tree falls and so exposes the loose sand again to the wind, or when the changing contour of the land sets the wind currents against some new and poorly protected spot, a great hole is blown out of the land and the sand is carried inland to be deposited in some new spot as a moving dune. These blow-outs (Fig. 14) are characteristic features, marked with the wreckage of former forests.

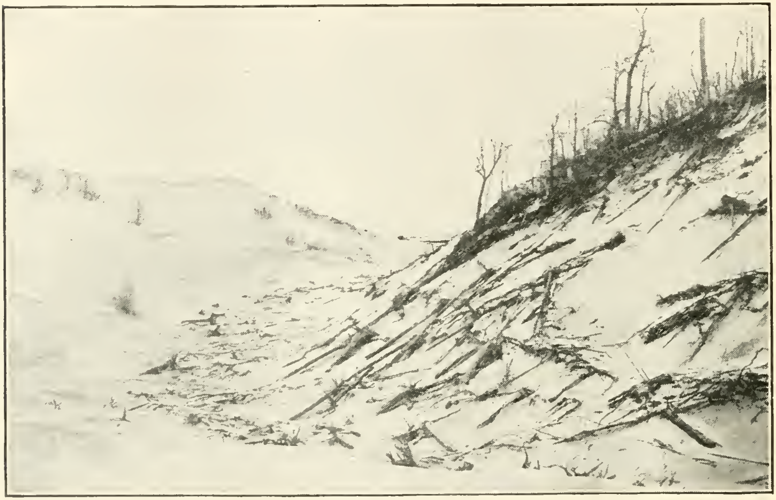


FIG. 14.—A blow-out in the dunes

As has been suggested above, these agents that wear away the land are also agencies of land formation. The ocean, whose waves pound the shore débris into sand and still finer mud, carries this material by its undertow and currents out into the quieter portions and drops it offshore in sand bars and mud banks. These deposits accumulate to great depths, hundreds and even thousands of feet in thickness. The rivers bring down their tons of material to add to the accumulation. Thus the

Mississippi discharges annually into the Gulf of Mexico as much débris worn away from the land in its course as would a thousand cargo ships each carrying ten thousand tons. Dip a pailful of water from the Des Plaines at Riverside when the spring freshet is on or from the Illinois at Starved Rock; let the suspended mud settle, collect it, dry it, and then weigh it, and you will be surprised to see how much soil one cubic foot of water is carrying. Measure the width of the stream, its average depth, and its rate of flow by getting the distance a floating chip goes in five or ten minutes; calculate from this data the volume of water that passes in an hour's time, then the weight of sediment it carries, and it foots up an incredible amount. All the streams that flow into Lake Michigan are ceaselessly filling in the lake. The wave action along its shores tends to make it wider, but also shallower since the eroded material is carried out to settle in the quieter, deeper portions. The constant necessity of dredging out harbors and their approaches is readily understood when one appreciates this incessant deposition.

The ultimate fate of a lake or pond is to be transformed into land as it is filled up by the material washed into it from the surrounding hills and by accumulating plant débris (Fig. 15). Becoming shallower, water weeds and rushes grow farther and farther out in it until it transforms into a marsh. Even then the filling does not cease, for each year's crop of marsh grass and water weeds piles up and, only partly decomposing, affords the following year a slightly higher footing for the next crop. Wolf Lake and Lake Calumet are both shallow and filling rapidly. Already many of their bays are marsh rather than pond areas. Indeed, along the margins of these lakes it is very easy to trace all stages from pond to prairie land.

The river builds land instead of eroding it wherever its current is checked. The carrying power of a stream depends on its rate of flow and its volume. The swift current can keep coarse material moving that is deposited when the movement is sluggish. When the stream flows into pond or lake, its rate of

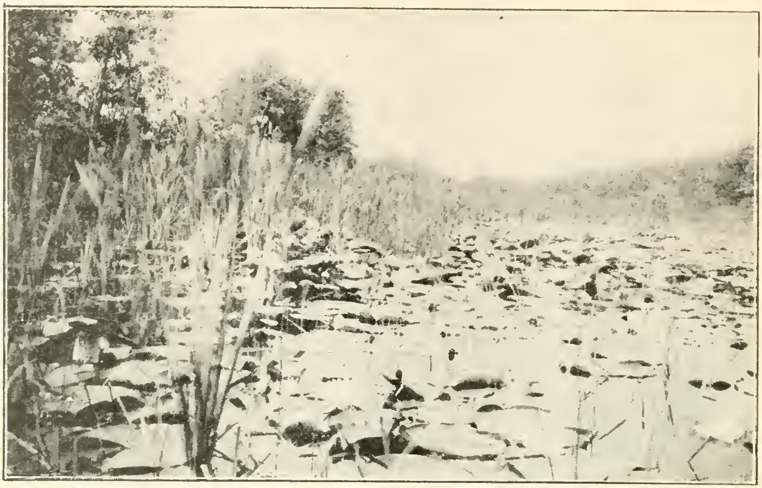


Fig. 15.—A filling pond, with water lilies and cat-tails growing in profusion

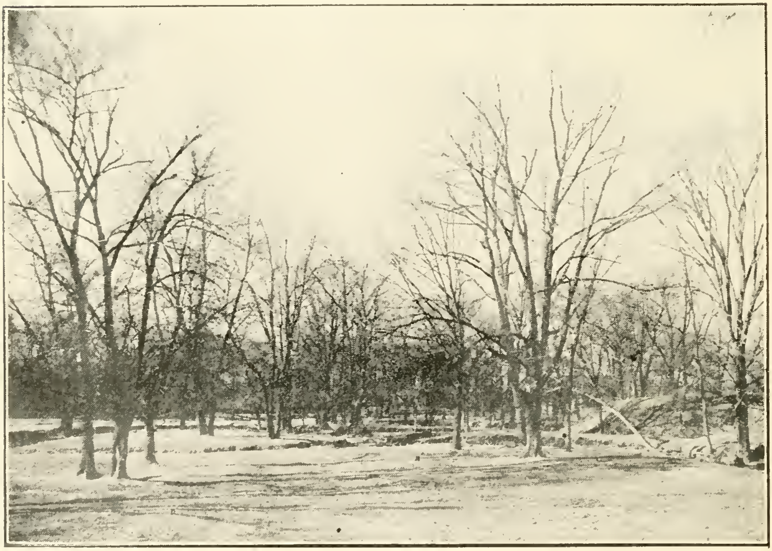


Fig. 16.—A flood plain where deposits occur during overflow. At the right the bluff marks the edge of the flood plain.

flow is lessened, in consequence of which a bar is often formed at its mouth or in larger streams, a delta. Deposits are laid down below an obstruction like a bowlder in midstream. While the stream cuts on the outside of a wide curve where its flow is rapid, it deposits on the inside where it is slow. Often the spring freshets raise the height of a river so it overflows its usual channel. The current beyond this is relatively sluggish so that over the flood plain there is formed a deposit of mud washed from the hills upstream (Fig. 16). This flood plain is frequently enriched by this annual addition of humus, so that river bottoms proverbially have good soil.

The accumulated soil and rock débris swept from a continent by the various agencies of erosion and transportation deposited in quiet bays or ocean deeps gradually transforms to rock again, so new lands are formed as old ones are destroyed. When extensive deposits accumulate offshore or in the deltas of great rivers, the very weight of material seems to cause the earth's crust to gradually sink. Thus the deposits may continue to accumulate, as is apparently the case in the Gulf of Mexico, until they become very thick. Then the lower mud layers, pressed upon by the thousands of feet of overlying layers, baked by the heat of the interior, since they are ever sinking farther from the surface, are transformed into rock in a way analogous to the manner in which we make brick or artificial stone, by compressing, then heating the mud or clay. So sedimentary rocks have formed, probably are forming in our Great Lakes now. Certainly they have so formed here in the Chicago region, for our dominant bedrock, the limestone, is of sedimentary origin.

Movements of the earth's crust often upheave these beds of mud transformed to rock, so adding to the surface of the land. The outer crust of the earth is relatively cool, the inner portion of the earth still exceedingly hot. Like any hot body it gradually cools, and cooling shrinks; so it tends to shrink away from the already cooled crust. This, of course, can never actually happen, for the heavy crust crumples down on to the shrinking central portion being thrown into folds, some of which thrust the rock layers up, some down (Fig. 17). These changes in level of the earth's crust sometimes are so sudden as to cause an earthquake, but usually they are so gradual as to be imperceptible except as comparisons are made at long intervals. The northern shores of Lake Michigan are now rising—have risen on the west side of the lake two feet or so in a generation. We know that the limestone that makes up the bedrock of the Chicago region, now dry land, was formed under the surface of the ocean, for it contains fossil remains of animals and plants, shellfish, and seaweed that live only in the sea. We shall see evidence of many changes in level in our region.

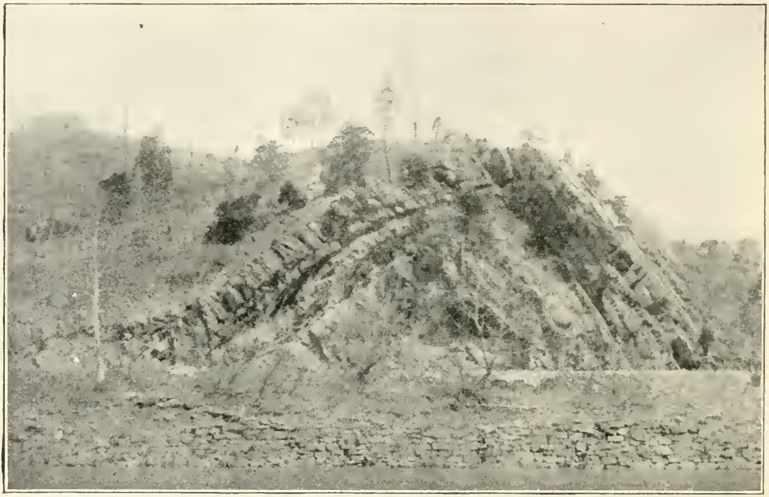


FIG. 17.—Up-arched rock strata

Along the Atlantic Coast there is evidence of a sinking shore. Stump lands along the coast are now completely under water. The Hudson River Valley is shown by soundings to continue well out to sea, its lower end having been "drowned" as the land sank there. Along the western coast of South America coral reefs are found well up on the sides of the mountains.

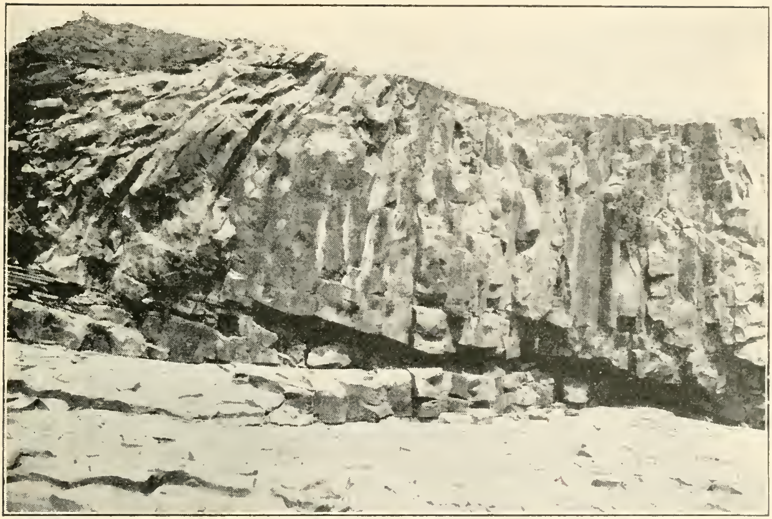


FIG. 18.—The edge of an old lava outflow, now basalt, covering a wide area

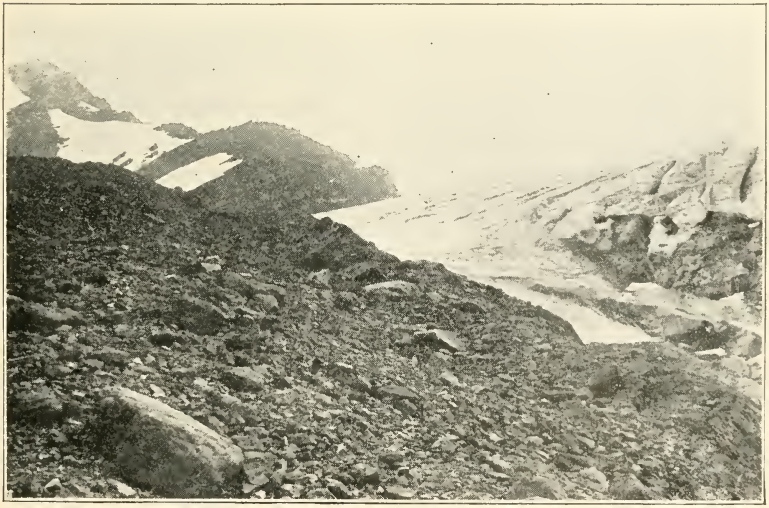


FIG. 19.—Glacial moraine in the foreground deposited by the glacier, right and rear.

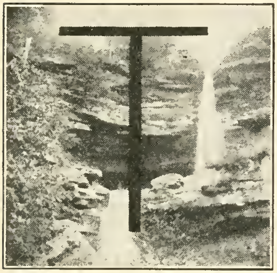
Evidently they must have formed below sea-level, and the mountains have been reared since then.

Volcanoes are another agency of land formation. The lava welling from their craters or from cracks in the earth pours out in great sheets (Fig. 18) while molten, only to harden as it cools into beds of rock. Fortunately for our peace of mind no volcanoes exist in the Chicago area, though we do have lavas, like the granite and greenstone glacial bowlders that have been transported by the ice from the old lava beds to the north of us into our region.

The glacier builds as well as destroys. The ice mass incorporates into itself the rock fragments torn from its bed and sides, so the onward moving river of ice is loaded with débris and abraded material. At some place it encounters a temperature sufficiently high to melt it as rapidly as it pushes forward. Here it must drop its load of rock powder and rock fragments and so it forms a great pile along its front, a terminal moraine (Fig. 19). Streams of water made by the melting ice pour out of gaps in the moraine on to the country beyond, carrying gravel and sand that are deposited in great fans or along the valley, if the outwashing stream follows such, in elongated heaps or valley trains. These and other forms of deposit characteristic of the glacier are found about Chicago as will appear in a later chapter.

CHAPTER II

THE WORLD IN THE MAKING



THE world passed through a long period of development before there were any oceans or rivers or atmosphere upon it to serve as agents of erosion or deposition.

The earth on which we live is one of several similar bodies called planets that move about the sun. These planets, in order from the sun outward, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Around many of these planets as centers there are other smaller bodies known as moons. The earth has one attendant moon, Jupiter four, Saturn ten. Planets and moons appear bright when seen from the earth, shining by the reflected light of the sun. The planets look like stars to the naked eye; the ones near our earth are very bright and are familiar as evening and morning stars. Our sun, on the other hand, shines because its substance is so intensely hot that it is perpetually emitting light. It is a true star and not a very large one either, but it is so near our earth, comparatively speaking, that its light and heat seem much greater to us than that of much larger suns or stars that are very far away. The diameter of one of the stars in the constellation Orion, Betelgeuse by name, recently measured by a newly devised instrument, is some three hundred times that of the sun. Sun and planets, moons, and some still smaller bodies that revolve about the sun together make up our solar system. Probably the other stars are also centers of planetary systems.

The eye unaided counts four or five thousand stars, but the telescope enables us to locate hundreds of thousands, and each new telescope more powerful than its predecessors adds to the number. These stars are themselves not fixed but are moving through space with terrific speed. Our sun, carrying the other bodies of the solar system along with it, is swinging along in its orbit at the rate of some twelve miles per second, but neither the size of its orbits nor its center has as yet been determined.

What a tremendous tangle of pathways is woven by these onrushing suns, their circling planets, and the moons that move about them. The criss-crossing railroads of our country present a simple maze in comparison. What a splendid opportunity for an occasional smash-up if two of the suns or two of the yet more numerous dark bodies should dispute with each other the right of way at some crossing of their pathways. Astronomers tell us that this sort of thing occasionally happens, resulting in the blazing out of a new star as two of the dark bodies rush headlong together, generating thereby enough heat to change their substance into a cloud of incandescent material.

Even more frequently two bodies will come close enough together as they rush by each other to disrupt each other, each being torn more or less to pieces by opposing forces, the momentum of its own precipitate motion in its pathway, and the attraction of the other body. It is from some such wreckage that our solar system is supposed to have originated. The largest remaining fragment or coterie of fragments dominated the rest and became the nucleus of reorganization, the central sun. About it, as a resultant of their original impetus and the force of mutual attraction, the smaller fragments revolved, drawing in turn about them the still smaller ones.

Our earth began, then, as a knot of dense material in the cloud of fragmented material. By its attraction it drew to itself the smaller bits about it and they moved toward it with increasing momentum, finally smashing down on to its surface. Gradually the earth nucleus grew as it accumulated these tiny revolving bodies, the planetesimals, whose pathways brought them within reach of its quite powerful attraction.

Naturally the great central mass, our sun, grew even more rapidly, for its pull was in proportion to its mass, so that it reached out in its might to draw to itself many times the number of planetesimals that the relatively small earth could reach.

This process has been going on for long ages and still goes on. The earth comes near some small mass moving in its orbit and by its tremendous gravity pulls it toward itself. It rushes toward the earth, passes through the outer air with such velocity that the friction heats it intensely; it continues to fall a burning mass and usually is consumed, but at times may reach the earth's surface. These bodies we call meteors or, improperly, falling stars; if a star should hit the earth we would not live to tell the tale. H. A. Newton estimates from his careful observations that sixteen millions of these meteorites enter our atmosphere every twenty-four hours. According to William H. Pickering they add over one hundred tons to the earth each year. "By far the most of them are so minute that they are consumed before they reach the ground, though about one thousand do that every year, some of them of considerable size." The meteorite that Peary brought down from the North now in the American Museum of Natural History, New York, weighs more than thirty-seven tons. There have probably been much larger ones.

Not far from Flagstaff, Arizona, is a remarkable crater-like depression [Fig. 20]. The rim of it, rising about 140 feet above the plain, can be seen from the railroad, passing Cañon Diablo. The depression has a diameter of about three-quarters of a mile, and the bottom is 500 feet below the top of the rim, 350 feet below the surface of the plain. No one can look upon this remarkable phenomenon without thinking of the craters of the moon. But there are no signs of volcanic action ever having taken place in this region; the thing is out of the question. The rim piled around the crater has not come from the interior of the earth, but is composed of sandstone, which in some way has been lifted above the plain. Some of the great masses of this sandstone have apparently been highly heated and crystallized, but most of the rock has been crushed and shattered. The whole neighborhood is sown with meteors.

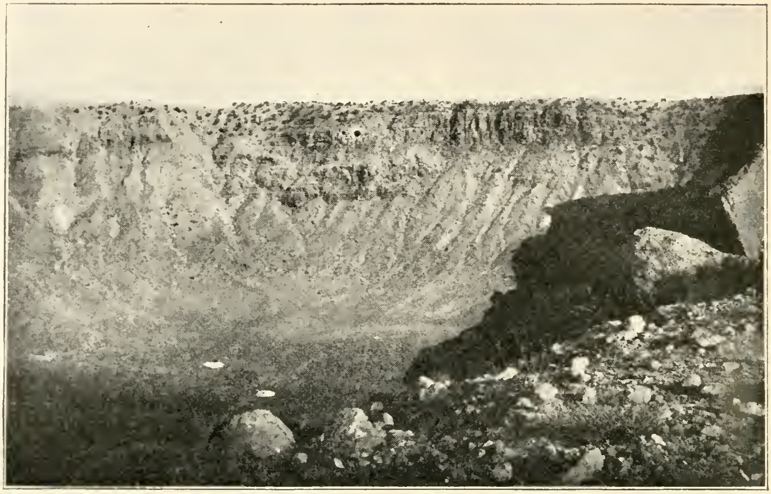


FIG. 20.—Portion of so-called "crater" of Cañon Diablo, probably made by the falling of a great meteorite.

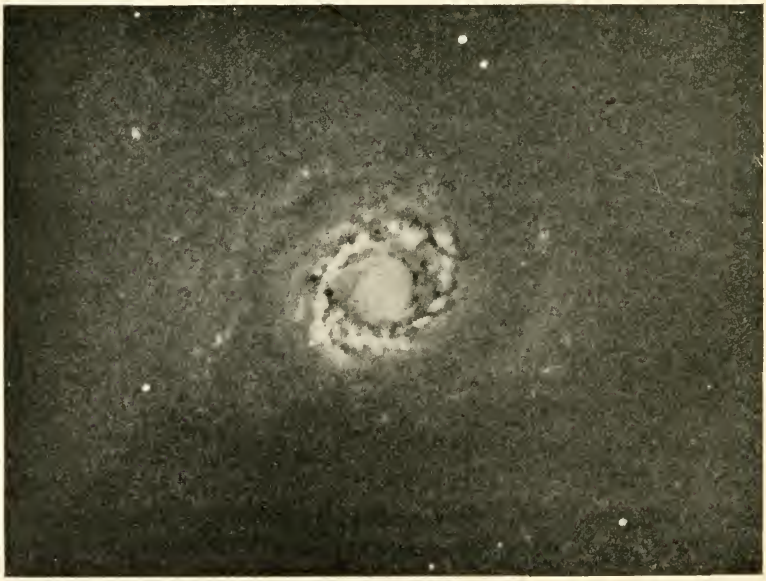


FIG. 21.—A spiral nebula with centers of condensation, the great central one giving rise to a sun, the others to planets and satellites. Photo by Mount Wilson Observatory.

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Without much question the depression and surrounding rim mark the spot where some huge meteoric mass has plunged into the earth. Lunar "craters" likely have had a similar origin.

So according to the planetesimal hypothesis our earth can trace her history back to the time when she was one of the larger knots of matter in the arm of a spiral nebula (Fig. 21). Because of the original size of this knot and the abundant meteoric material her changing orbit brought her into, she grew apace as falling planetesimals were added to her bulk, and now she is the fifth largest of the planets in our solar system. Jupiter, the largest, is more than thirteen hundred times the size of our earth. Saturn, Neptune, and Uranus are also larger. Venus, Mars, and Mercury are smaller.

As the earth thus grew in size it also became hot. The succession of blows delivered by the hail of planetesimals generated heat, as the anvil becomes hot under repeated hammer strokes or a nailhead is heated when the nail is being driven into hard wood. This heat was superficial and quickly radiated. The central portion of the earth was, however, constantly being pressed upon by the overlying accumulating mass. As the earth grew constantly by accession the central portion was condensed more and more. We are all familiar with the fact that heat makes things expand. The mercury in the thermometer bulb expands more than the glass and so rises in the tube with increased heat. The opposite of this is also true: as substances condense heat is liberated; so the earth's interior became heated. The condensation of the central mass also caused molecule to rub against molecule as crushing went on and so added to the central heat. The pressure was so great near the center that the rock material could not actually melt. But nearer the surface, especially where up-arching of the crust relieved the pressure temporarily, the rock material melted, oozed up toward the surface, infiltrated between the piled-up chunks and dust, cementing these into a solid mass as the molten material cooled. Thus formed, likely, the early igneous rocks.

If we should make an ideal section of the earth at this early stage (Fig. 22) the surface layer would be very irregular, due to the indiscriminate infalling of planetesimals. The next zone would be very porous, similar to the contents of a basket filled with large potatoes, only the fragments would be vastly larger, more or less cemented with lava. The zone below would be less porous, as the planetesimal matter would be pressed together by the weight of the zone on top of it. The central core of the planet would be very compact, due to the pressure of the zones above it. The diagram shows the later rock layers on the outside of this early earth.

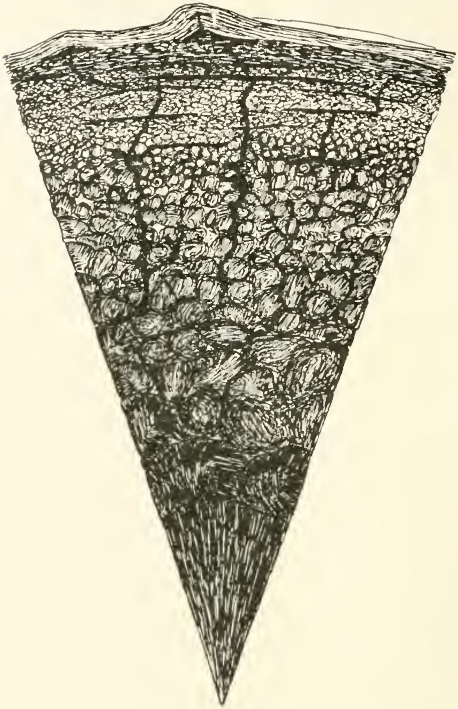


Fig. 22.—Diagrammatic section of the earth

Meanwhile the young earth, growing, reached a stage when it doubtless could hold the beginnings of an atmosphere. As the earth's gravity gradually increased it would first be able to hold the gases that are heaviest and least volatile. Carbon dioxide is the heaviest of all the gases that make up our atmosphere. Oxygen is next in weight; then nitrogen, water vapor, and hydrogen follow in succession. The earth is still not large enough to hold much hydrogen.

When the earth had reached such a size as enabled it to hold water vapor the atmosphere was piled high with clouds. Rains poured upon the surface only to evaporate promptly, it was so hot. Gradually the surface cooled sufficiently so water could remain. Then the little drops of water congregated in the spaces between the rocks in the upper zone. Gradually these cracks were filled with water and the water overflowed and formed little pools. The pools grew into lakes, and the lakes joined each other and formed oceans.

The torrential rains washed the rock not covered with water and formed rivers that carried the sediment down and deposited it on the rocks under the oceans. This continued long ages. In this way the ocean floors had the weight of the waters upon them and the added weight of the deposited material. This made them sink, deepening the ocean basins and pushing up the land masses, making the continental platforms higher.

Now, no sooner were the continental areas raised above the ocean level than all the agencies of erosion were turned loose upon them. The waves beat upon the land, the rain pounded it, the brooks and rivers furrowed it, underground waters honeycombed it, in time snowfields thrust out huge ice sheets to grind down the hills and deepen the valleys, frost shattered the rock cliffs, the gases of the air united with the rocks to alter them into soft materials easily eroded, earthquakes rent the land, the sand-laden winds, the chemical action of organisms growing on the rocks—these all aided in the rock disintegration and soil formation and prepared for the transportation of materials by these same agencies to lower levels and finally to the lakes and seas.

This process of transportation was as incessant as erosion. Ponds and lakes constantly filled up with the wash from the uplands. Rivers carried immense loads of sediment into the oceans. The United States Geological Survey estimates that the material washed from the surface of this country and carried off by the rivers annually amounts to over one-quarter billion tons. And so the material that was originally rock and had been eroded, transported, and deposited began to form rock again. The deeper layers of those vast accumulations of sediment in ocean deeps, in inland seas, and great bays were under the terrific pressure of the overlying layers and fathoms of ocean waters. They became intensely heated, for they were far enough below the surface to feel the heat of the earth's interior, retained by the blanket of overlying layers. So they were transformed into rock.

These beds raised the temperature of the older underlying rocks almost to the point of fusion, establishing a line of weakness here so that as the crust movements, due to unequal shrinkage, occurred these areas of weakness were readily upheaved, the sedimentary rock strata were arched, sometimes crumpled, and thrown up above the sea.

Similarly all over the earth the sedimentary rocks, formed in successive geological ages, have been upheaved and occasionally exposed to our inspection. These rocks often contain fossils, the remains of animals, and plants that lived in past geological times. Such animals and plants living in the water or washed from the land into the streams possibly by spring freshets were carried seaward and deposited with other débris, with sand and silt in the great mud banks in lakes and oceans. These, by the process outlined above, were changed to stone, and so the bones or shells of animals, the bark, fruits, and even leaves of plants have been preserved, gradually assuming a stony texture (Fig. 34, 36). Or if the softer parts rotted away, the cavity left filled in with rock in time and so made a cast of the organism showing to this day all the delicate details of the original. These fossil remains, when carefully studied, yield an interesting history of living things upon the earth. The science which deals with these fossil remains is paleontology, a special department of geology.

Our western plains are, in places, particularly rich in the fossil remains of some of the great vertebrates. Scarcely a summer passes that scientific expeditions are not organized to go out and explore these regions and find the fossils. The scientists of the expedition then skilfully remove them from the rock, often spending days in chiseling away the rock from around the cast of some old bones or in cementing together the more or less cracked remains so they may be transported safely. They are then shipped to the great museums, where they can be leisurely set up and carefully studied.

The paleontological record is at no place on the earth complete. It would seem at first thought as if in digging deep mines we might hope to begin excavations in rocks of recent formations and then dig down deeper and deeper through successively older rocks. So we could find animal and plant remains that would enable us to reconstruct readily the history of living organisms. But the task is not so simple.

In an ideal section of the earth's crust (using the term in the sense of the outer accessible layer) we should find the oldest rocks deep down, then later and later rocks in successive layers upon them, and finally the very recent rocks at the surface of the earth. Such a condition is purely ideal; it exists only in the mind of the geologist. It is fortunate that this is so, for if the oldest rocks were always buried miles and miles deep under the layers of later formations we could know nothing about them. As it is they have often been upheaved and recent rocks have been eroded off from them. The rock layers, by violent upheaval, have been turned upside down in places so that the older rocks are on top.

Whenever the sedimentary rocks with their fossil remains have been upheaved above the ocean level, the process of deposition has been thereby stopped and so the fossil record has been interrupted. Moreover, no sooner were these rocks lifted above the ocean than erosion began, and the historical record that had been made was rapidly destroyed.

Thus the paleontologist reads the history of life upon the earth from a great book whose leaves are the rock strata on which, in fossil characters, the record is inscribed. Just as ancient human history must be patched together by the experts from fragmentary bits, a clay tablet dug up from some old ruin in the Euphrates Valley, some bit of papyrus taken from an Egyptian pyramid, some roll unearthed from ash-covered Herculaneum, so must this geological record be constructed out of authentic scraps of information gathered from the rocks of the several continents. Much of the record is covered up under layers of soil and is inaccessible. Only in the quarry, the mine, the chance exposure of rock strata by railroad cut, the river gorge, or mountain ledge can the explorer find the fossil remains. These give opportunity for the study of a mere fraction of the whole record. It is surprising that the geologist has been so successful in reconstructing the history of life upon the earth in the face of such difficulties.

The historian divides the time of the enactment of human history into the modern age, the medieval, the ancient, back still farther, an age of myth and folklore in which events are dimly seen, and finally a prehistoric age when the happenings must be matters largely of conjecture. So the geologist subdivides the history which he reads in the strata of the earth's crust into the Cenozoic, Mesozoic, Paleozoic, Proterozoic, and Archaeozoic eras. Then just as man subdivides historical ages into smaller periods, as for instance the age of ancient history, into the Babylonian period, the Egyptian period, the Grecian and Roman periods, so the geological eras are subdivided. The tabulation at the end of the chapter will show the main divisions and subdivisions of geological time and will serve as reference to place the events about to be recorded. It will also facilitate the reading of the bulletins in the bibliography at the end of the book.

The different rock strata are referred by the experts to various of these time divisions according to the time of their formation. Thus we speak of carboniferous rocks—those that were deposited during the Carboniferous period. The relative age of any rock layer is determined by finding what rocks are below it, what are above it, and by the character of the fossils it contains.

Under the eras, periods, and their subdivisions are given at the left the names of the better-known formations belonging to each, mostly those of the eastern states, while at the right are those of Illinois and adjacent regions. Unless the names are identical, those on the same line in the two series are not to be taken as necessarily equivalent.

CENOZOIC ERA	
Quaternary	
Recent period	
Pleistocene period	
Tertiary	
Pliocene period	
Miocene period	
Oligocene period	
Eocene period	
MESOZOIC ERA	
Cretaceous period	
Comanchean period	
Jurassic period	
Triassic period	
PALEOZOIC ERA	
Permian period	
Upper Permian	
Rustler	
Castile gypsum	
Lower Permian	
(Brazos or Oklahomian)	
Delaware Mountain	
Dunkard shales, sandstones, and limestones	
Pennsylvanian period	
Monongahela shales, sandstones, and limestones	
Conemaugh shales, sandstones, and limestones	McLeansboro series, including clay, limestone, slate, sandstone, and the LaSalle first-vein coal, also known as Streator No. 7
Allegheny shales, sandstones, and limestones	Carbondale series, clay, limestone, slate, sandstone, and LaSalle

Pottsville sandstone or conglomerate (Millstone grit)	second- (Springfield No. 5) and third-vein (LaSalle No. 2) coals, the latter just above the Pottsville series, including clays and sandstone
Mississippi period	
Upper Mississippian (Chester series)	Typically exposed in southern Illinois
Grand Rapids series in Michigan	Kincaid limestone
	Degonia sandstone
	Clare limestone
	Palestine sandstone
	Menard limestone
	Waltersburg sandstone
	Vienna limestone
	Tar Springs sandstone
	Glen Dean limestone
	Hardensburg sandstone
Marshall series in Michigan	Golconda limestone
	Cypress sandstone
	Paint Creek limestone
	Yankeetown formation
	Bethel sandstone
	Renault limestone
	Aux Vases sandstone
Lower Mississippian (Iowan series)	
Meramce	
St. Genevieve limestone	Names of formations are for the most part the same in the Central West
St. Louis limestone	
Spergen sandstone	
Warsaw	
Osage	
Keokuk limestone	
Burlington limestone	
Fern Glenn limestone	
Kinderhook	
Chautauquan limestone	
Hannibal shale	
Sulphur Springs sandstone	
Louisiana limestone	

Devonian period	
Upper Devonian	
Chautauquan series	
Catskill sandstone	
Chemung sandstone or shale	Mountain Glenn shale
Senecan series	Alto formation
Portage sandstone or shale	
Genessee shale	
Tully limestone	
Middle Devonian	
Erian series	
Hamilton shale	Lingle limestone
Marcellus shale	Misenheimer shale
Ulsterian series	
Onondaga limestone	Grandtower limestone
Schoharie grit	Dutch Creek sandstone
	Clear Creek chert
Lower Devonian	
Oriskanian series	
Esopus grit	
Oriskany sandstone	
Helderbergian series	
Becraft limestone	Backbone limestone
New Scotland limestone	Bailey limestone
Coeymans limestone	
Silurian period	
Upper Silurian (Cayugan)	Monroe series, Mich.
Manlius limestone	
Rondout limestone	
Cobbleskill limestone	
Salina beds	
Middle Silurian (Niagara)	
Guelph dolomite	Guelph dolomite
Lockport limestone	Reef limestone
	Upper coral beds
	Lower coral beds
Rochester shale	Sexton Creek
Clinton beds	Edgewood

Lower Silurian (Oswegan)	Girardeau
Brassfield sandstone	
Medina sandstone	
Edgewood limestone	
Tuscarora	
Cataract sandstone or shale	
Becksie limestone	
Ordovician period	
Upper Ordovician (Cincinnatian)	
Garoche	
Richmond limestone	Richmond shale and shaly limestone (Maquoketa)
Mayville or Loraine	
Eder or Utica shale	
Middle Ordovician (Champlainian)	
Collingwood limestone	Kimmeswick and Platten
Trenton limestone	Galena limestone
Black River dolomite	Platteville limestone
Lowville limestone	
Chazy limestone	
Stones River limestone	
St. Peter sandstone	St. Peter sandstone
Lower Ordovician (Canadian)	
Fort Cassin dolomite	Shakopee dolomite, cement rock, and sandstone
Beekmantown or Prairie du Chien dolomite	New Richmond sandstone
Oneota limestone	Oneota dolomite
Madison sandstone	Jordan and Madison sandstone
Mendota limestone	St. Lawrence dolomite
The last three are possibly to be put in a separate period, the *Ozarkian*	
Cambrian period	
Upper Cambrian (Croixian) mostly limestones	Franconia glauconitic sandstone Potsdam (Lake Superior sandstone)
Middle Cambrian (Acadian) mostly limestones	
Lower Cambrian (Waucobian)	
	Dresbach shale and sandstone
	Lowest sandstone

PROTEROZOIC ERA

The chief rock systems in this era in the Great Lakes region are in northern Michigan, Wisconsin, and Minnesota. In northern Michigan they are as follows:

- Upper Keweenawan
  - Freda sandstone
  - Nonesuch shale
  - Outer conglomerate
- Lower Keweenawan
  - Lake shore trap (basic lava)
  - Great conglomerate
  - Eagle River and Ashbed group (acid lava intrusives)
  - Mesnard epidote
  - Central mine group (basic lavas)
  - Conglomerate (acid lava intrusives)
  - Bohemia Range (mostly basic lavas)
- Upper Huronian
  - Clarksburg formation
  - Michigamme slate and schist
  - Goodrich formation (mostly quartzite and conglomerate)
- Middle Huronian
  - Presque Isle granite
  - Quinnisec schist
  - Tyler and Hanbury formations
  - Negaunee, Vulcan, and Ironwood formations
  - Ajibik, Siamo, and Palms formations
  - Hemlock formation (basic lavas)
  - Kona, Randville, and Bad River formations
  - Mesnard, Sturgeon, and Sunday formations (mostly quartzite)

ARCHAEOZOIC ERA

- Laurentian
- Keewatin

CHAPTER III

THE STORY OF OUR ROCK FOUNDATION

THE rock immediately underlying the soil in the Chicago area is the Niagara limestone. It has a thickness of 250–400 feet. It is exposed in many places about the city as in the quarries at Stony Island, Thornton, Hawthorne, Elmhurst, on the Chicago & North Western Railway; McCook, on the Atchison, Topeka & Santa Fe Railway; and Lockport, on the Chicago & Alton Railroad. There are mile-long heaps of it beside the drainage canal from which it was excavated from Willow Springs to Lockport, and also beside the branch canal from Blue Island to the Sag. At Lockport the rock comes to the surface and forms the bluffs bordering the Desplaines River Valley on the south, and there are similar bluffs on the north side of the valley at Lyons. As a rule the strata of the limestone are approximately horizontal, dipping slightly to the south. But at Stony Island they are sharply inclined (Fig. 23) and that in opposite directions on the two sides of the present low ridge, showing that this elevation is the eroded remnant of what was once a mountain fold of no mean height. Similar folds of the strata on a smaller scale are seen in many of the quarries.

Below the Niagara limestone occurs a succession of rocks which in a deep boring at Lockport were disclosed as shown in the accompanying diagram (Fig. 24). Other similar borings have given like results. Presumably if the drill had gone deeper it would have encountered the still older rocks of the Proterozoic era and then the complex of the Archaeozoic. The history of the formation of these rocks of our immediate vicinity is most interesting.

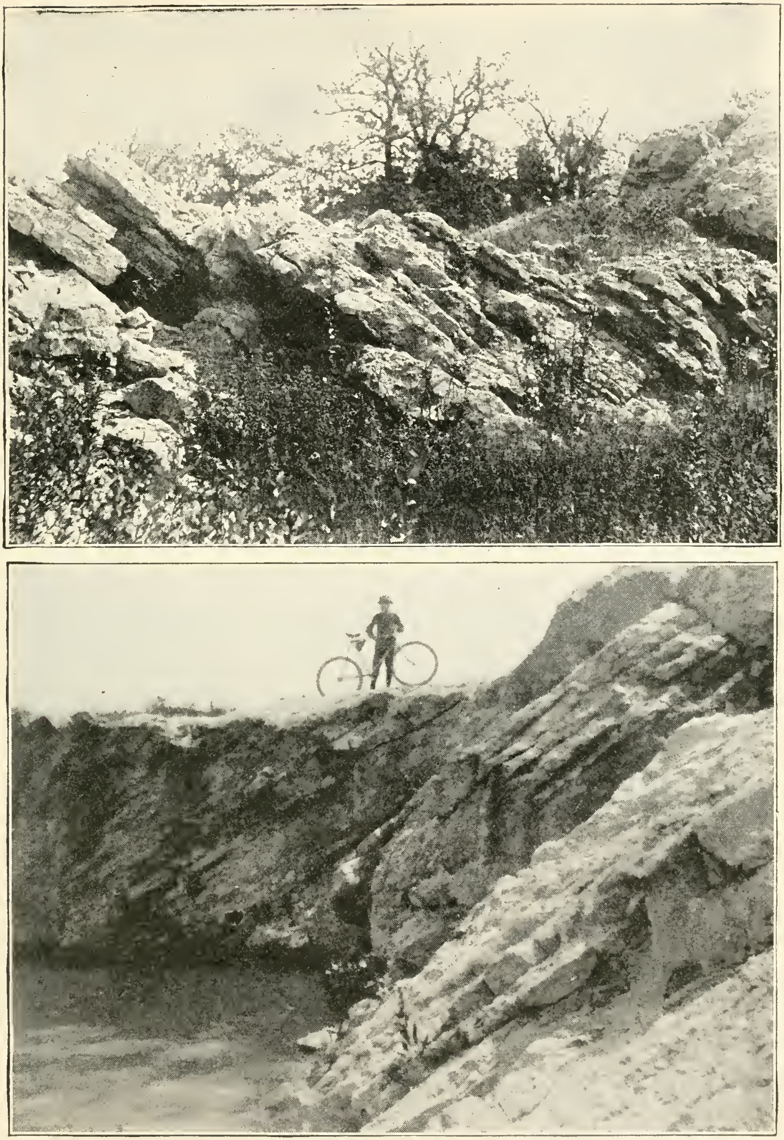
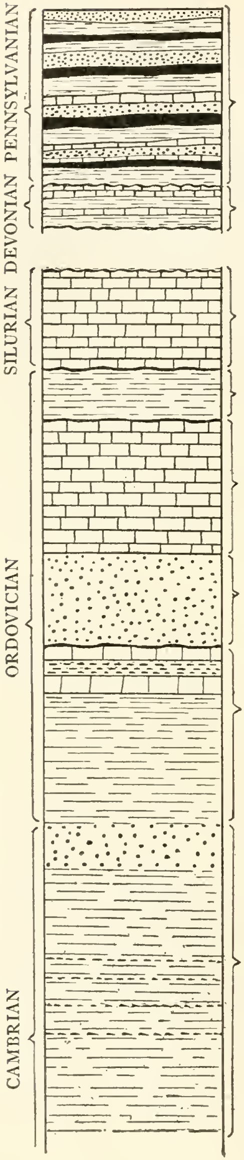


FIG. 23.—The east and west quarries on Stony Island. Note the strata dip in opposite directions.



Sandstones, limy shales, limestones and coal.

Limestone and shales.

Below this level are the rock strata of the Chicago area as revealed in a well bored at Lockport (after Alden, U.S. Geological Survey). Above strata found to south and east; the Devonian is slightly represented at Chicago.

Niagaran, dolomitic limestone	230 ft.
Richmond (Cincinnati) shale	110 ft.
Galena-Platteville (Trenton) limestone	300 ft.
St. Peter sandstone	210 ft.
Lower Magnesian formation Dolomitic limestone, red marl, and shale, or shaly limestones.	395 ft.
Potsdam formation Sandstone, red marl, and shale or shaly limestones.	686 ft.

Fig. 24.—Diagram of strata in the Chicago region

Concerning the earliest rocks that made up the outer cool portion or crust of our earth we know nothing except by inference, for they are nowhere subject to observation. Probably they were lavas that had outflowed from the deeper layers on to the surface, forming not only what lands there were, but also the bottoms of the seas and oceans. These rocks were attacked by the various agents of erosion, and disintegrated. The material so eroded was used to build up other rocks as indicated in the preceding chapter. These newer rocks, sandstones, shales, etc., such as are forming today under similar conditions, accumulated through long ages, were upheaved by the crumpling and folding of the crust, occasionally into great mountain ranges, and thereby metamorphosed into quartzites, slates, and schists. The rock layers were by the same convulsions fractured, and into the

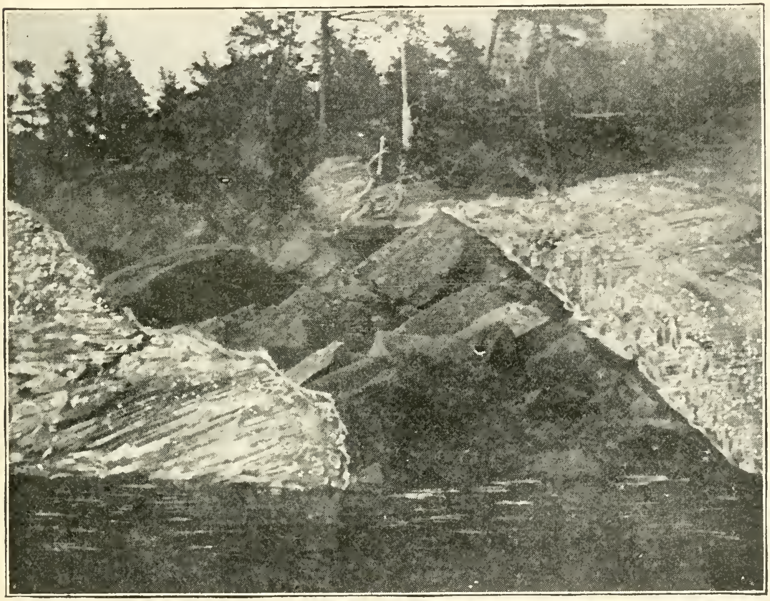


Fig. 25.—Basaltic dyke intrusive in granite, the latter lichen-covered, south shore of Partridge Island (Marquette), Lake Superior.

great cracks and crevices fresh lavas forced their way, often separating the strata, raising the upper ones as domes and filling the spaces so formed. So these rocks where they are accessible today are seamed with dykes (Fig. 25), as these cooled lava intrusives are termed, and where their upper layers have been removed by erosion the old masses of lava that filled the domes stand up as rounded hills or monadnocks (Fig. 26).

How often this process of rock destruction, reformation, and metamorphosis was repeated we do not know. In time simple plants and animals appeared. Through their action beds of carbonaceous material—probably peat—of iron oxide, and of magnesian limestones were laid down with the sandstones and shales. These also were transformed by metamorphosis into graphites, iron ores, and dolomitic marbles. The early lavas, granites, diorites, and such were in many cases also greatly altered by later strains and stresses, to which they were subjected by crustal movements. So the earliest rock masses to which we have access consist of highly metamorphic quartzites, slates, schists, marbles, seamed and infiltrated with granites and with basic lavas that are often so abundant as to dominate the formation. These old rocks are so folded, crumpled (Fig. 27),

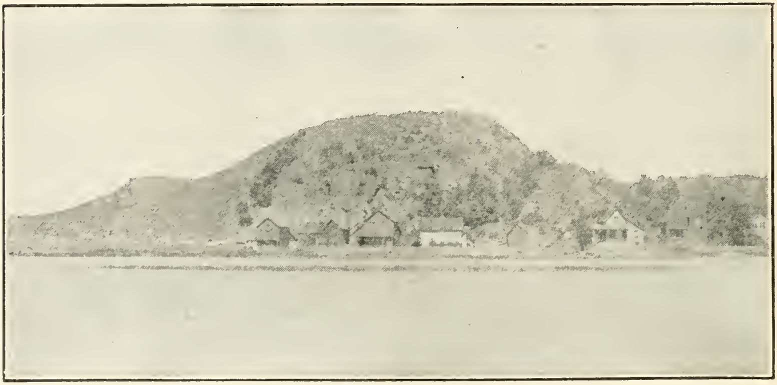


Fig. 26.—A monadnock, Ishpeming, Michigan

and eroded that we may now often examine their upturned edges as they become exposed. The accessible rocks of these early eras are exceedingly thick, possibly one hundred thousand feet thick, thicker than all the formations that came after them. The amount of erosion that they have undergone is tremendous. Rock layers miles in thickness have been removed from these early land masses that were of continental proportions. Presumably then, the Archaeozic and Proterozoic eras represent longer periods of geological time than any of the later eras, and are to be counted in tens of millions of years, possibly hundreds of millions.

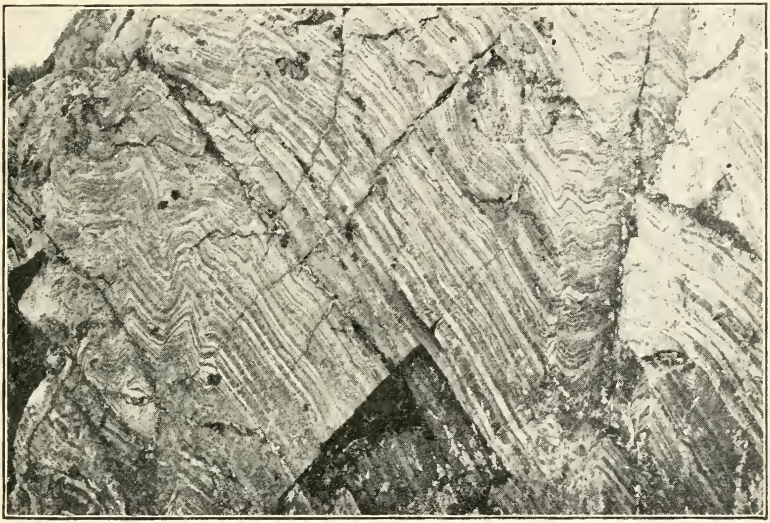


FIG. 27.—Folded and crumpled rock on the face of a vertical cliff of jasper and hematite at Ishpeming, Michigan.

The early lands, made up of these primitive rocks that served as the nuclei for the formation of the North American continent, were a group of great islands. In general the oceanic depressions and the continental elevations have existed from Archaeozoic time, possibly from the very first, much as they now are. These islands, therefore, arose from a shallow sea that covered the continental elevations. In this sea on the flanks of these early nuclei were deposited the materials eroded from them that made up the succeeding formations of the early Paleozoic, somewhat as nowadays in the Gulf of Mexico or the Mediterranean are accumulating the deposits of mud that in all probability will in time transform to rock which may be upheaved to form new land masses.

In general it may be said that the rocks of the later eras—Paleozoic, Mesozoic, Cenozoic—were laid down in the North American region in these shallow epicontinental seas, seas that constantly changed their shape as the surrounding lands were raised or depressed by crustal movements, or as the ocean changed its level when its floor sank or rose, in which latter process accumulating sediments were a major cause. Sometimes the land above the ocean was a group of islands, sometimes it was a continent with more or less of its central area covered by a sea and this latter was connected by wide straits with the Atlantic, Pacific, the warm tropical ocean, the cold Arctic, one at a time or two or more simultaneously. The characters and affinities of the animals and plants whose remains are found in the successive rock formations give us the best evidence regarding the oceanic connections of the seas in which these formations were deposited.

The large island made up of the Proterozoic rock complex nearest to the Chicago region was extensive, covering what is now northern Wisconsin, a part of the upper peninsula of Michigan, much of Minnesota, and a large area extending northward into Canada. This region now consists of quartzites, shales, schists, and dolomites with the intrusive granites, diorites, and other lavas. If one were to start, say, at Stevens Point or at Grand Rapids, which places in Wisconsin mark about the southern limit of the exposed Proterozoic rocks in our vicinity, and travel southeastward to central Illinois, he would pass over he edges of the succession of rock formations laid down one on

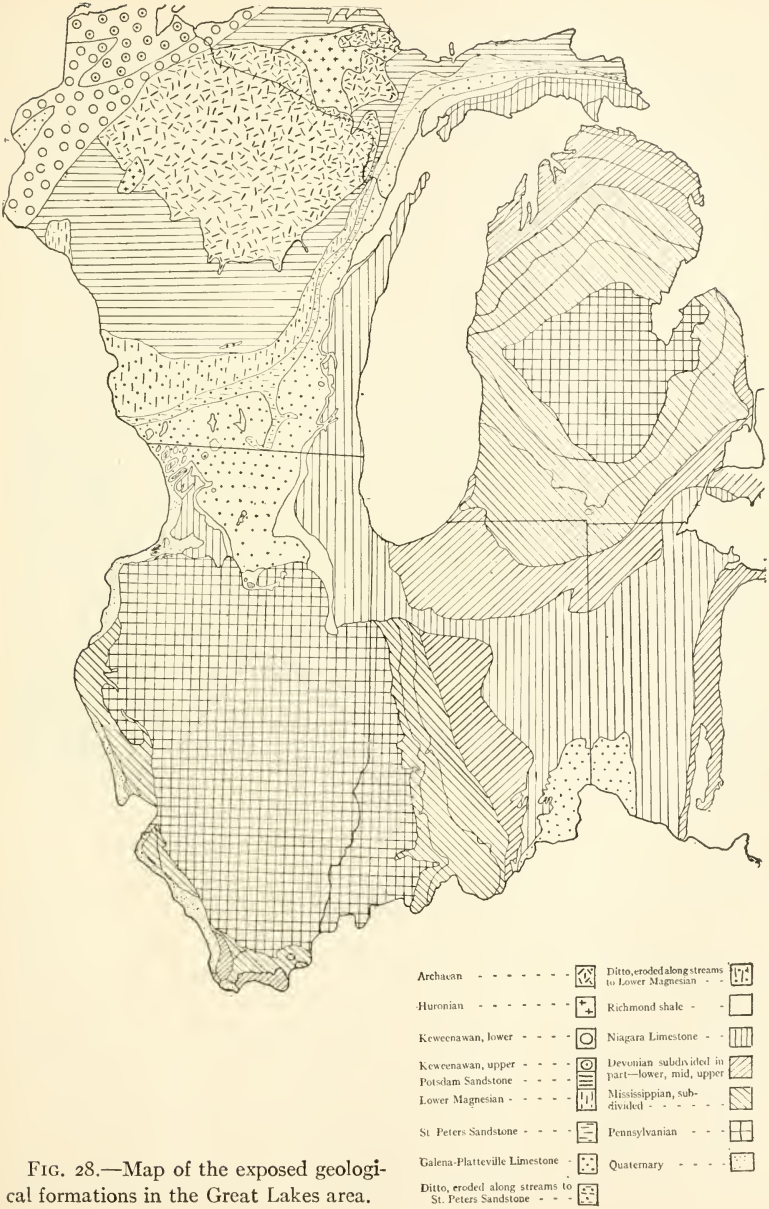

Archaean
Ditto, eroded along streams to Lower Magnesian
Huronian
Richmond shale
Keweenawan, lower
Niagara Limestone
Keweenawan, upper
Devonian subdivided in part—lower, mid, upper
Potsdam Sandstone
Lower Magnesian
Mississippian, subdivided
St Peters Sandstone
Pennsylvanian
Galena-Platteville Limestone
Quaternary
Ditto, eroded along streams to St. Peters Sandstone

FIG. 28.—Map of the exposed geological formations in the Great Lakes area.

top of another but with many interruptions on the southern flank of this continental nucleus (map, Fig. 28, compare Fig. 37). The underlying formations would not everywhere be the same because in some places the surface rock is one of those deposited early, and consequently has few members of the series below it, and in other places (those farther south), the rock is a later formation and has many members below it. Often one or more members of the series may be absent at a given locality if that spot was land when said member was being deposited as might readily be the case since the sea was so incessantly changing its shape from period to period.

When such a term as the Niagara limestone is used it does not imply that the formation is necessarily homogeneous; it may consist of successive strata of different sorts of rock or, if of the same sort, the succeeding layers show by the unlike animal and plant fossils they contain that they belong to different successive fragments of geological time. The Niagara limestone, the bed rock of the immediate Chicago region, was laid down in this interior sea without any very violent interruptions, but the outlet of the sea was shifted several times during its deposition so that the fossil remains in successive levels of the formation are quite unlike, some having affinities with arctic forms, some with tropical, and some with those of the Atlantic and Pacific. The formation is thus divisible into several distinct sets of strata. In the Chicago region there are at least the lower coral beds, the upper coral beds, the reef limestones (Fig. 29), and the Guelph. Similarly, the Potsdam sandstone exposed farther north consists of three quite distinct sets of strata, the lowest sandstone that has a thickness of about a thousand feet, the Dresbach shale and sandstone, and the Franconia sandstone, the two latter each about two hundred feet thick. The names applied to the successive rock formations encountered in Illinois and adjacent territory are shown in the table at the close of the preceding chapter.

The character of the rock often tells much of the conditions prevailing at the time of its formation. Beds of sand and gravel are usually deposited in the ocean nowadays close inshore, unless the streams bringing in the sand are swift or unless rapid ocean currents carry the sand well out from the shore line. Fine mud may be carried in suspension long distances by the water. It settles only in the quiet parts of the ocean, which are usually the deepest ones, or in isolated bayous free from the turbulence of the waves, from currents, and from undertow. Limestone is made up of the more or less completely ground up shells of animals like clams, oysters, and other similar forms, or the hard parts of corals or of other animals whose skeletons are composed largely of lime. By pressure and infiltration this pulverized material is later transformed to the limestone. Now animals like corals and clams will not live where the water is very muddy. Corals especially must have fairly deep and clear water in which to thrive. Wherever an area of limestone is found, especially if it contains coral beds *in situ*, it means that the body of water at whose bottom it formed must have been fairly deep and sufficiently far removed from the shore line to be beyond the deposits of sand or any large amount of mud.

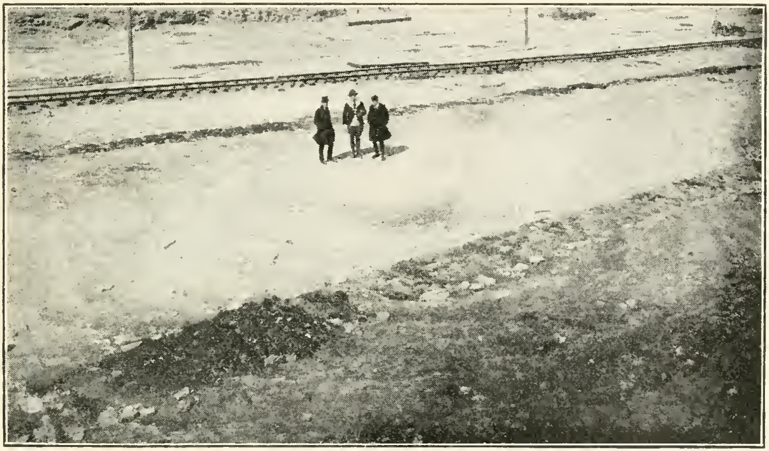
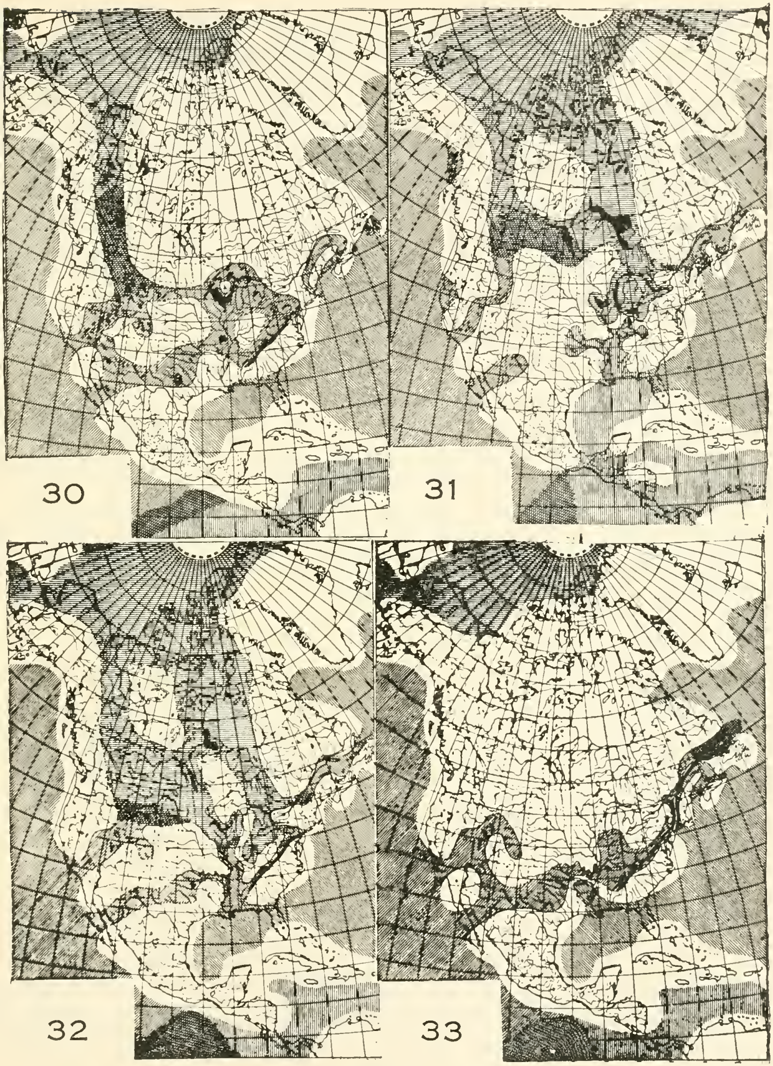


FIG. 29.—A coral reef exposed in the quarry at Thornton, Illinois. Men are standing at the center of the concentric lines of growth. Photo by Link.

With these brief hints of the sort of evidence on which the geologist relies to reconstruct the physiographic features of past ages we may sketch in bare outline the history of the Chicago region and adjacent territory during the time the rocks hereabouts were depositing. During the Acadian period (Fig. 30) the Potsdam formation, largely sandstone with shales, was laid down as sand and mud washed by erosive agencies from the adjacent land and spread out on the sea bottom and transformed into rock. Then followed the Canadian period (Fig. 31), during which limestones, sandstones, and shales were formed. The conditions must, of course, have frequently changed to permit of such varied types of deposits. First there were laid down thick beds of magnesian limestone interrupted by layers of shale and marl when evidently the sea became shallower and muddy or possibly even so shallow as to allow abundant vegetation that was instrumental in forming the marl. Later sandstone formed and then more limestone.

There was next (Ordovician period) a change to a shallow sea with swiftly flowing currents and a nearby shore. The sea contracted and its margins transformed to dry land. Possibly much of the time the sea completely disappeared from this locality, its shores lying farther south, and the drifting sand blew inland in great dunes covering wide areas. This sand in time solidified to form St. Peter sandstone. Again the land sank and the interior sea reformed, inundating the entire area about us as well as areas considerably to the north. The sea bottom was now deep enough along shore and free enough from mud to allow the abundant growth of animal and plant life. Here where Chicago stands were forming great beds of limestone, the Platteville-Galena (Trenton) made of the wave-worn fragments or even of the perfect shells or skeletons of animals then living along the shores, the nearest of which were somewhere up in what is now mid-Wisconsin. Animal life was abundant. There were corals, brachiopods, pelecepods, and trilobites. There were also extensive beds of seaweed growing luxuriantly just as



Figs. 30–33.—Fig. 30.—Map showing land and sea when the Potsdam sandstone was depositing (Upper Acadian). Fig. 31.—When Magnesian limestone was depositing (Beekmantown). Fig. 32.—When Richmond shales were depositing (Cincinnatian). Fig. 33.—When part of the Niagara limestone was depositing (Mid-Silurian). Land is white, sea finely lined; black shows areas of present outcrop. All after Schuchert.

they do now along the coral banks of the Gulf of Mexico. No fish were swimming in the waters; they had not yet appeared upon the earth. The land areas would have seemed strange, too, for the vegetation did not consist of trees and grasses and flowering herbs, but lowly plants like algae, liverworts, and ferns. No insects were flying, no vertebrates, neither snakes nor frogs nor birds, had yet evolved.

Toward the close of the Ordovician period another extensive change in level of the sea occurred. The central sea decreased in size in this region though widening in the north (Fig. 32), coastal plains emerged hereabouts, and from them and across them great quantities of mud were washed so the shallow sea became unfit for many animals. Many kinds were forced to migrate to deeper seas, many perished, and their remains are very abundant in the beds of shales and sandy limestones known as Richmond shales. This stratum formed in the Chicago region to a depth of 100 feet and elsewhere in the interior sea became even thicker.

The formation of the Richmond shales and sandstone was terminated by a rise of the land so that the northern portion of the interior sea including the Chicago region became dry land, subject then to the destructive forces of erosion. So closed the Ordovician period, and the Silurian period was ushered in. As it advanced the sea deepened rapidly (Fig. 33) until conditions were favorable again for an abundant animal life along the shore and for corals in the deeper waters. Many, many generations of animal forms with calcareous skeletons lived and died and left their shells or other hard parts to form the thick deposits that later transformed into Niagara limestone to a depth of from 250–400 feet in the Chicago region.

This rock is full of fossils that help us gain a clear idea of the animals that lived upon the sea bottom where today Chicago stands and that contributed their skeletons and shells to help form the rock out of which Chicago's inhabitants constructed their buildings in the days before cement so largely replaced building stone (Fig. 34).

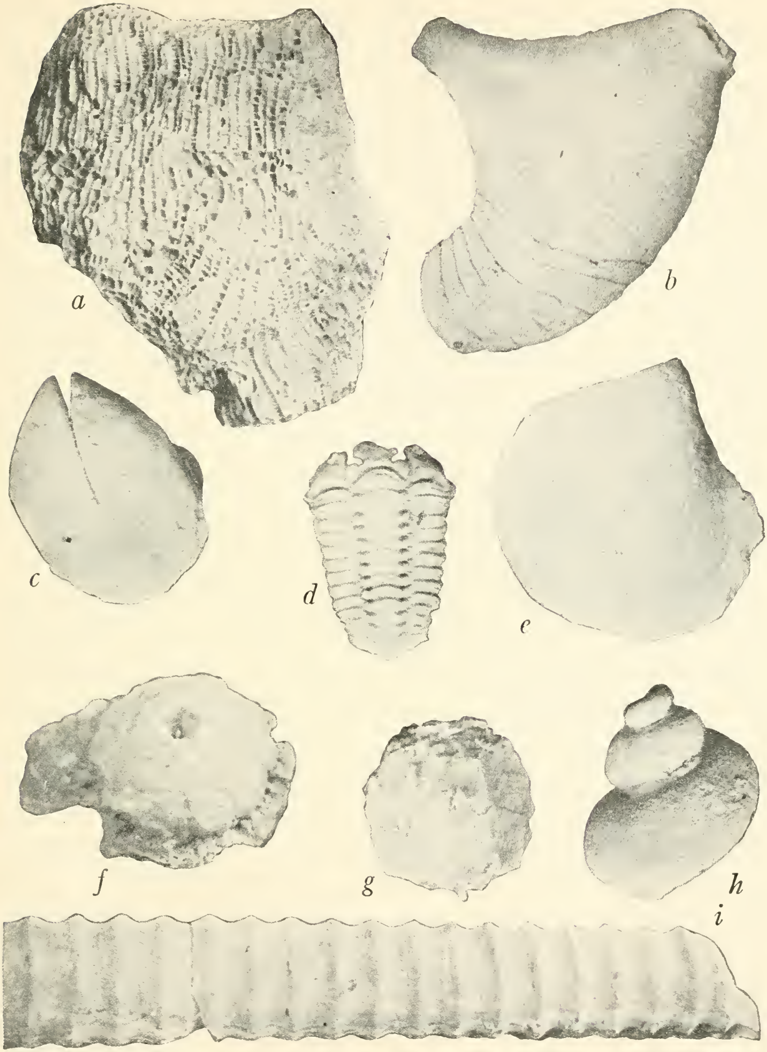


Fig. 34.—Animal fossils from Niagara limestone in the Chicago region. *a*, a coral, *Favosites niagarensis* Hall; *b*, *Phraginoceras nestor* Hall; *c*, *Pentamerus oblongus* Sowerby; *d*, a trilobite, *Calymene celebra* Raymond; *e*, *Amphicoelia neglecta* McChesney; *f* and *g*, crinoids: *f*, *Eucalyptocrinus asper* Weller; *g*, *Caryocrinites ornatus* Say; *h*, *Strophostylus levatus* Hall; *i*, a straight-shelled cephalopod, *Dawsonocerus annulatum* Sowerby. Photo by Fenton.

There were great reefs of corals off the shore of the nearby land, and other species of corals that lived solitary lives rather than in colonies were abundant. There were sponges, graptolites, polyps, crinoids like stemmed starfish, ordinary starfish, lamp shells or brachiopods, clams, snails, cephelopods, somewhat related to the pearly nautilus of today, only having long, straight shells instead of coiled ones; there were primitive crustaceans like the trilobites. Undoubtedly on the land about the sea grew giant club mosses, tree ferns, cycads, and the lower types of flowering plants such as the conifers and the grasses. Centipedes and lowly types of insects were also probably seen.

A period of upheaval followed the deposit of the Niagara limestones closing the Silurian period, and the Chicago region was once more dry land undergoing erosion. How long this condition persisted it is hard to say, but there followed another period of depression when the sea again occupied this site. The inland sea was becoming more restricted, however, deposition was going on in limited basins, and the wash from the land was increasing as the land area grew. In this Devonian period the strata formed consisted of shales and limestones. Only remnants of them exist in a few locations about Chicago, however, for the sea disappeared in our region rather promptly and all the Devonian rocks that had formed were eroded away leaving the Niagara limestone bare except where an occasional fissure in it had happened to receive and retain some of the Devonian deposits. Such have been found at the quarry at Elmhurst and at Lyons. These deposits, though scanty, are exceedingly interesting, for they contain many sharks' teeth, local evidence of the presence of the fishes in the Devonian seas; they were so abundant, so dominant, that the Devonian is known as the age of fishes.

So far as we know, the ocean never again overflowed the site of Chicago. This immediate region remained exposed, subject to the action of the elements, undergoing extensive erosion during the rest of the Paleozoic and during all of the Mesozoic and the Cenozoic. Our local rocks afford no evidence of the changes that occurred through all these eventful ages, except the tokens of the glacial period that came in late Cenozoic time, as will be described shortly.

The whole central region of Illinois is occupied by rocks of the later Paleozoic era (map, Fig. 28) commonly known as the coal beds. The seas (Fig. 35) in which these rocks were deposited were at times sufficiently deep to allow mud deposits to accumulate that later were transformed to shales and slates; then again they became so shallow they were covered with swamp vegetation. Here grew dense jungles of cycads and calamites, rushes and sedges, gigantic ferns and probably conifers, a rank growth whose trunks and stems and leaves falling into the shallow water accumulated until a thick bed of vegetable matter lay upon the floor of the sea. This was covered by mud during the next period of depression and gradually by pressure and heat was converted into coal.

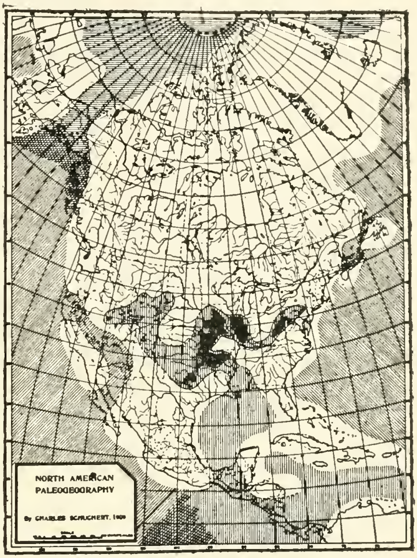


FIG. 35.—North America in the Upper Pennsylvanian when the Illinois coal beds were being deposited. Land white, seas lined. Black areas indicate land where these strata are now surface formations. After Schuchert.

The old dump piles of refuse slate, shale, and poor coal afford excellent opportunities to secure fossils of this period. Fern leaves, bark of the tree-fern trunks, calamite stems, fossils of various animal types, including an occasional fish skeleton, and that of the early amphibians are to be had by patient search (Fig. 36). You can easily imagine the picture of the region when the coal was forming: the dark swamp forest, the moist, warm air heavy with abundant carbon dioxide, tree ferns, cycads, grasses, rushes—an almost impenetrable jungle—a loose, swampy soil, a vegetable slush into which the fallen trunks sink, insects somewhat like roaches crawl over the vegetation—some like immense dragon flies are darting about in the air.

In the adjacent sea are sponges, corals, graptolites, sea urchins, starfish, crinoids, brachiopods, clams, snails, trilobites, shrimps (Fig. 36*e*), cephalopods, fish of the lower types, amphibians, and boring in the mud banks are sea worms of various sorts.

Centuries passed by in the Chicago region, hundreds of them. In the distant seas were forming the thousands of feet of rock strata that make up the remainder of the Paleozoic, the Mesozoic, and the Cenozoic rocks. Undoubtedly the rocks of the Chicago area, disintegrated slowly under all the processes of weathering, formed deep soil, and upon this there grew a rank vegetation. Here, in time, occasionally perhaps roamed those huge reptiles whose fossils are to be seen in the collection of the Field Museum and still later various types of mammals that were precursors of present-day forms. The map (Fig. 28) gives the positions and relations of the main formations occurring as surface rocks over a wide area about Chicago.

A great fold of the strata occurs in Illinois, a broad up-arching, its axis running southeast-northwest and continuing into Wisconsin on the one hand and into Indiana on the other. The rock originally lying on the top of this arch has been removed by erosion as a result of which, it will be observed, there is in the northern part of the state a broad central band of Galena-Platteville limestone bordered on the east and west by the Richmond (Maquoketa) shale, while farther out still lie bands of the Niagara limestone on the eastern one of which Chicago is situated (see Fig. 37).

The nearest point to Chicago at which the Richmond shale is found is in the neighborhood of Joliet, at the mouth of Rock Run, near the old canal some four miles southwest of the city and in the same neighborhood in an abandoned quarry near

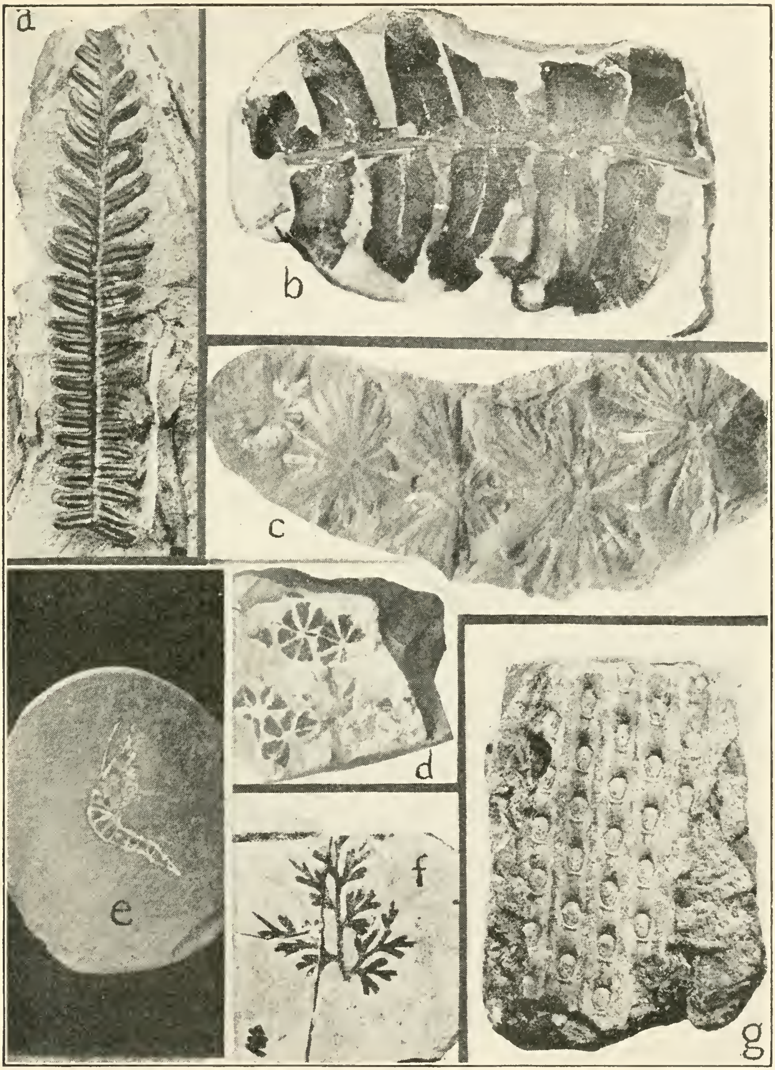


Fig. 36.—Fossils from the Pennsylvanian coal measures, Mazon Creek, Ill. All plants except *e*. *a*, *Alethopteris ambigua* Lesqx.; *b*, *Neuropteris vermicularis* Lesqx.; *c*, a horsetail, *Annularia stellata* Schl.; *d*, *Sphenophyllum marginatum* Brougn.; *e*, a crustacean, *Acanthotelson stimpsoni* M. & W.; *f*, *Palmatopteris furcata* Potonid.; *g*, bark of *Sigillaria sillimani* Brougn. Plant photos by P. O. Sedgwick.

the lower end of Flathead mound where, however, it is nearly covered by the crumbling Niagara limestone above it.

The map will show the nearest point at which the Galena-Platteville is exposed. In several counties along the crest of the arch the streams have cut down sufficiently to expose the St. Peter's sandstone that underlies the Galena-Platteville and in a very few spots to expose the deeper Lower Magnesian limestone (Prairie du Chien). Such cutting to the St. Peter's occurs in eastern Carroll County, in Ogle County south of Oregon on the Rock River, and along many streams in southwestern Wisconsin. The cutting runs deeper, even to the Lower Magnesian on the Illinois River in the neighborhood of La Salle and Utica. Between these it is exposed along the railroad tracks. It is also seen near the mouths of several creeks flowing into the Vermilion River.

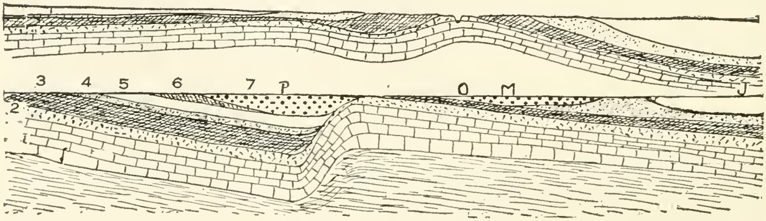


Fig. 37.—Diagrammatic section across the arch of rocks in Illinois. The lower section cuts through Joliet (J), Marseilles (M), Ottawa (O), and Princeton (P). The upper one is farther north. (1) Lower Magnesian formation; (2) St. Peter's sandstone; (3) Galena-Platteville formation; (4) Richmond shale; (5) Niagara limestone; (6) Devonian; (7) Pennsylvanian.

The Illinois is here flowing through country of which the surface rock belongs to the Pennsylvanian coal measures, so the river has cut through these, through the Galena-Platteville limestone and St. Peter's sandstone, to the Lower Magnesian limestone. The rocks of the Pennsylvanian formation are most easily reached from Chicago at Braiderwood or Coal City, on the Chicago & Alton Railroad and Atchison, Topeka & Santa Fe Railway, respectively, where they may be examined in the rock dumps of the coal mines. The rocks of the Devonian and Mississippian are older than the Pennsylvanian but are not exposed in the state nearer than its western side near Rock Island. They are found nearer Chicago, in Wisconsin just north of Milwaukee, and also in southwestern Michigan. Remnants of the Devonian rocks are preserved occasionally in the cracks and crevices of the Niagara limestone in this immediate vicinity.

CHAPTER IV

THE GLACIAL PERIOD

GREAT glaciers came out of the north in recent geological time covering all the northern part of North America (Fig. 38), Europe, and Asia, glaciers comparable to the great ice cap that now covers all the antarctic lands or to the one that still over-rides Greenland. The glacial period probably came on gradually. The snow accumulated in the north more rapidly during the long winters than the summer's diminishing heat could melt it. It grew deeper and deeper. The chill of the great snowfields was felt in the lands south of them where the climate became more rigorous and the snows began to pile up; thus the snowfields became more extensive. In the far north the snow banked up miles deep until the lower layers under the terrific pressure were transformed into ice and were squeezed out, moving southward over once fertile lands and transforming them into arctic desolation. This same process is going on now on a small scale in the high mountains all over the world where lakes of snow in the upper valleys outlet by rivers of ice that slowly push their way down the slopes (Fig. 10).

What agencies brought on the glacial period has been a matter of interesting conjecture. The uplift of the northern part of the continent to Alpine height, a shift of the warm ocean currents so they did not flow into the northern oceans, a change in the position of the earth's axis so that winter came in the northern hemisphere when the earth in its orbit was farthest from the sun instead of nearest as now, a change of eccentricity of the earth's orbit, an increase in the amount of carbon dioxide in the atmosphere which would shut out much of the sun's heat—all these have been suggested as possible causes, and each has been judged more or less incompetent to produce the results. Possibly several causes co-operated to produce the glacial age. It is estimated by Penck that a reduction in the average annual temperature of less than 15° F. would bring on a return of the glacial period in North America, a slight change apparently to produce such far-reaching consequences.

If the exact causes still are matters of debate, the fact is certain that the Chicago area was covered with a deep glacier and that not once but several times, for there is good evidence that a succession of glacial periods have followed each other in North America. These have been designated the Aftonian or Jerseyan, the Kansan, the Illinoian, the Iowan, and the Wisconsin. The oncoming of the Wisconsin ice sheet occurred possibly twice as long ago as has elapsed since the last ice disappeared completely here, a matter of some ten thousand years. The Iowan began, roughly, four times as long ago; and the Illinoian, eight times or more. The time in which we live may be one of the interglacial periods, and it may be that many of the mighty works of our much vaunted civilization will, in the distant future, be blotted out by the renewed ruthless advance of the great ice cap.

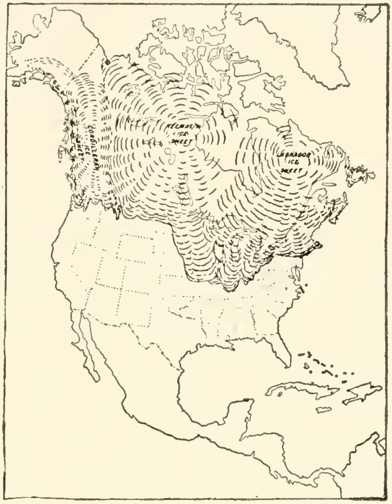


Fig. 38.—Map of North America at the time of the glacial period. Note that the southern limit of the glacier was a little short of the southern boundary of what is now Illinois and Indiana and that there was an unglaciated area in Wisconsin and northwestern Illinois. (See Fig. 51.)

While, as suggested in the last chapter, there is no evidence that rock strata were laid down in the Chicago region after the Devonian period of geological time, in the long stretch of ages that elapsed between then and the onset of the last glacial period many changes were going on in the area. For many centuries the forces of erosion were active. The Devonian rocks and possibly later ones on top of them were worn away until only vestiges of them were left and the removed material was carried off into the oceans. The surface of the hard Niagara limestone and of the softer Richmond shale was dissected by the rivers into steep-sided valleys that later broadened and became less abrupt while rounded hills of goodly height stood between. The rocks gradually disintegrating through hundreds of thousands of years formed deep soil. Vegetation flourished and animal life found abundant shelter and food. Probably where Lake Michigan now stands was a broad and fertile valley.

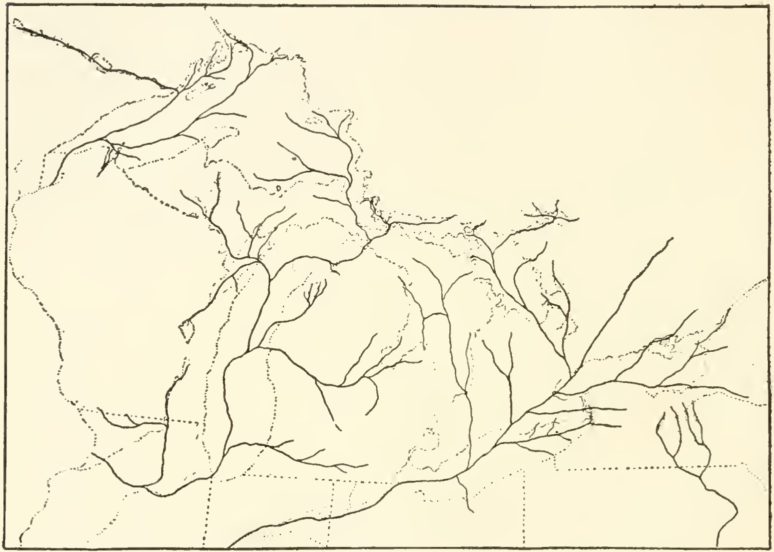


Fig. 39.—An attempted reconstruction of the preglacial drainage of the Great Lakes region. Present lakes, streams, and boundaries in dotted lines.

It is now impossible to be certain of the topography of the country hereabout before the glacier came to make its changes, for that old surface was undoubtedly greatly altered, its rock foundation pretty completely covered by the débris the glacier left. Still, knowing the general lay of the old rock strata and their nature, and learning something from the rock hilltops that crop out of the glacial deposits and from well borings that penetrate to the rock surface, it is judged that the old valley now occupied by Lake Michigan extended past the site of Chicago, through rugged hill country, and that in it flowed a river, part of the preglacial river system, a more or less conjectural diagram of which is shown in the accompanying figure (Fig. 39). Fortunately there is one region not far removed from Chicago which presents no evidence of the recent glacier, and it is believed it escaped the late ice covering—an island in the broad ice flow. This is the unglaciated region of northwestern Illinois and southwestern Wisconsin. It is a well-drained region with much branched rivers flowing in deeply cut valleys between the rounded hills. It is not a region of lakes or ponds. The soil grades insensibly into the rock—fine soil on top, coarser below, finely broken rock, coarser fragments, then the rock ledge just beginning to disintegrate. It is probably quite typical of the Chicago region in preglacial times except that the processes of erosion had not gone so far here before they were interrupted by the onset of the glacier.

As the great glacier came pushing its way southward it shoved ahead of it some of the soil scraped from the land, soil that had been accumulating through many centuries of rock decay; or else the frozen soil, together with the rock fragments below it, was over-ridden by the glacier, frozen to its base, and so became a part of the onward-moving mass and ultimately was incorporated in the plastic ice. Then this same material became in the grip of the glacier, an efficient grinding and polishing tool, This is found to be true of present-day glaciers. They are mighty agents of erosion. While the ice itself glides over the bed rock with little wear or tear, rock fragments held by the ice make deep grooves, imbedded sand grains striate the rock surface in the direction of glacial motion, while finer particles like clay polish it. Such work necessarily wears away the graving tools. Rock fragments held by the ice and pressed against the rock over which it moves are themselves planed off, polished, and scratched, first on this side, then on that, as they turn in the somewhat plastic ice. Ultimately they are ground to powder unless they are dropped in the morainal material, in which case they are subangular stones more or less marked by their use (Fig. 40). The bed rock where freshly uncovered in the Chicago region often shows a polished surface, sometimes striated, occasionally deeply grooved, mute evidence of events that were transpiring here during the great ice age. In general these markings are parallel and have a northeast-southwest direction,

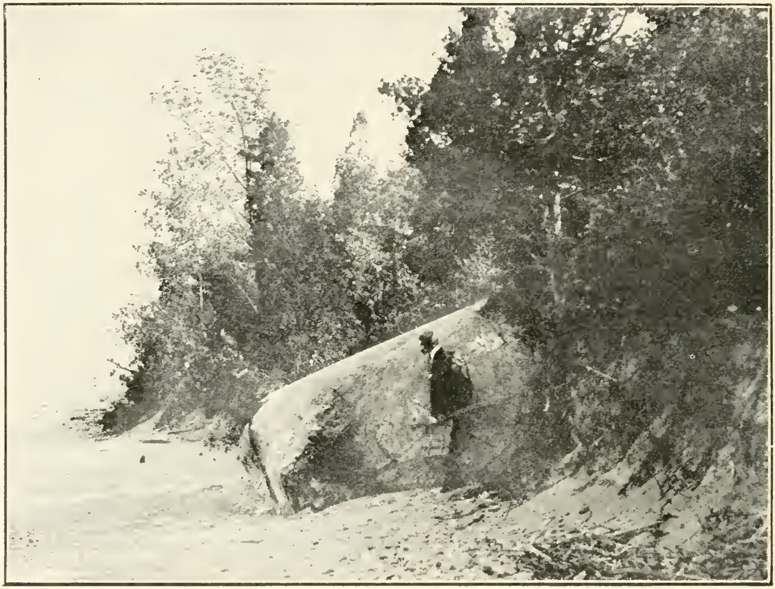


Fig. 40.—A good-sized glacial bowlder on Lake Michigan shore near Glencoe

showing the compass point from which the glacier came here. At times the scratches cross each other, indicating at least local changes in the direction of movement of the ice (Fig. 41).

At last in its onward flow the glacier pushed its way southward into a region so warm that the front of the glacier melted away as rapidly as new ice arrived. The bulk of the coarse rock fragments it was carrying, together with much of the finer stuff, was deposited along this line where the glacier front stood perhaps for hundreds of years, piling up in great unsorted heaps as the moving ice continually brought fresh supplies. Thus it formed out of this débris pillaged from a continent the terminal moraine. The Illinois glacier is the first one to leave undisputed evidence of itself in our state; it pushed south approximately to the present location of the Ohio River and deposited its terminal moraine. This glacier, therefore, extended past our present loca-

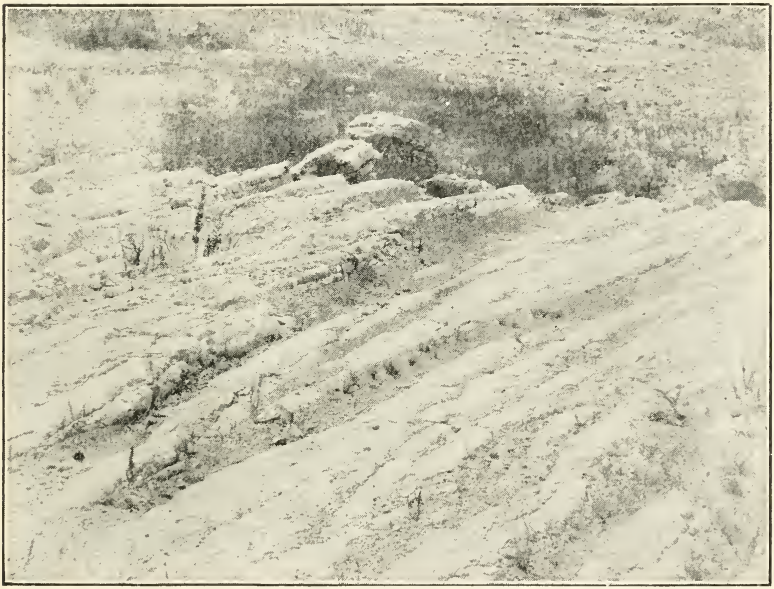


FIG. 41.—Grooves and scratches on bed rock due to glacial erosion, Stony Island, Chicago.

tion at Chicago some three hundred miles. Nansen found in crossing Greenland that the ice surface rose for the first 75 miles from the west coast nearly 90 feet per mile, then at a decreasing

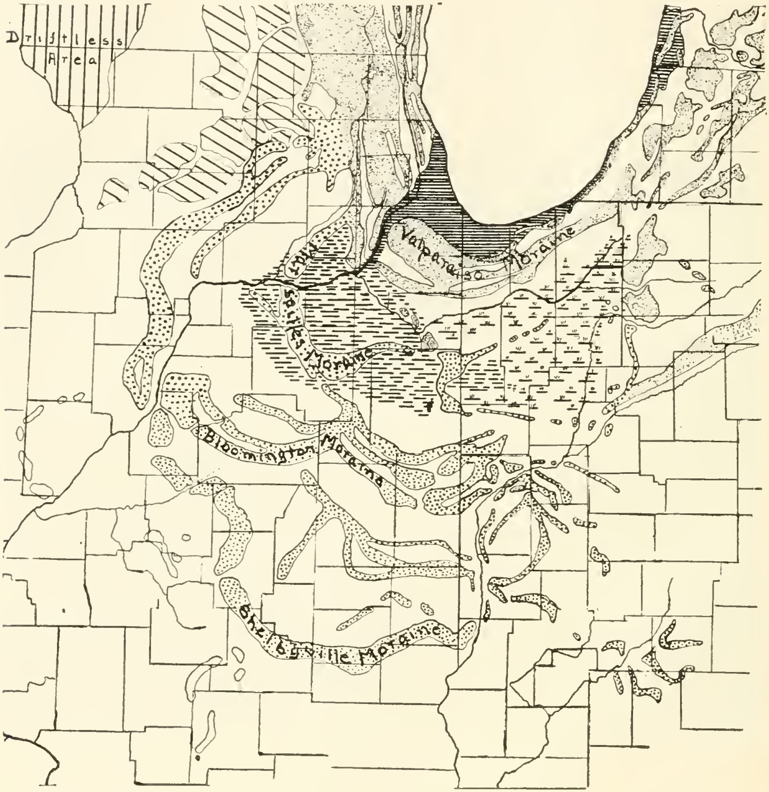

Driftless Area
Valparaiso Moraine
Marseilles Moraine
Bloomington Moraine
Shelbyville Moraine

FIG. 42.—The moraines of the glacier about south end of Lake Michigan; old Lake Chicago in heavy horizontal shading, Lake Morris in broken horizontal lines.

rate averaging 26 feet per mile. On this basis of calculation the ice of the Illinoian sheet at Chicago must have been about twelve thousand feet deep. Even if, to be on the safe side, this estimate were cut in half, it would still make the mass more than a mile in thickness, a ponderous thing, capable of over-riding hills and planing down their tops, of gouging out valleys, and of transporting incalculable loads of débris.

Gradually the rigorous climate of this early period was mollified. Spring came earlier as the years passed and the autumn days grew warmer, so that the glacier beat a slow retreat. As the front slowly melted back through many, many years the rock and soil débris held in the ice was deposited all over the smoothed and scored rock surface in an unsorted condition, the finer material containing subangular rocks and bowlders of all sizes, polished and scratched. It is the same sort of drift that makes up the terminal moraine but now constitutes the ground moraine, the deposit laid down by the retreating glacier. This withdrawal of the ice was irregular; it would fall back only to advance again as a few cold winters reinforced its reserves. Its front was constantly shifting as melting or temporary advance went on at some points more rapidly than at others, due to local conditions. The deposited drift was therefore left in erratically arranged heaps with irregular hollows between. The drift sometimes buried great blocks of ice which later melted, leaving depressions. Most of the valleys were without outlets except as chance arranged them, so that later they were occupied by lakes, ponds, bogs, marshes, and swamps.

This Illinoian ice age was followed by a long interval when the surface of the soil was subject to erosion; when in all probability forests developed and grassy plains and valleys lay luxuriant in the warm sunshine. Other ice sheets again invaded the region, however, bringing desolation. In these later ages, the Iowan and the Wisconsin, the ice in the Chicago region was nowhere nearly as thick as in the case of the Illinoian. These later ice sheets apparently over-rode the early drift deposits, piling up their moraines and other deposits upon the earlier ones. The average depth of the drift in the Chicago region is probably 130–140 feet, as determined by wells, with a maximum thickness of somewhat over twice this figure. Most of this is the deposit of the Wisconsin period. In some places in our immediate region it is underlaid by a deposit that has been regarded as belonging to one of the earlier ages, probably the Illinoian. A coarse conglomerate made up of glaciated pebbles, 5–10 per cent of which are of granite or diabase, is seen underlying the Wisconsin drift north of Lockport just beside the Chicago and Joliet trolley line and at several points within the city limits of Joliet, one opposite the brick switch house about a mile north of the Rock Island Depot. This deposit is well cemented together with carbonate of lime, transforming the original bed of gravel into rock. Its surface is said to give some indication of having been abraded by the later ice sheet. It seems more probable that these deposits are part of the valley train described below.

The surface features of the Chicago area are chiefly due to the deposits of the last of the great glacial periods—the Wisconsin—and to postglacial changes in these. The front of this ice sheet retreated by several steps, standing still long enough several times to make a succession of terminal moraines as seen on the accompanying maps (Figs. 42, 43).

> Each of the moraines marks a stage in the recession of the ice border, when the rate of melting was temporarily checked and the edge of the ice became nearly stationary. At such times the drift, which was being moved forward to the melting border and deposited there, accumulated to great thickness. When the ice border receded a relatively smooth lowland was laid bare behind the belt of thick drift. This extended to the point where another halt of the ice caused the making of another ridge of drift.

Of these moraines the last formed—the one nearest Chicago, the Valparaiso moraine—is the highest and broadest. It marks, evidently, a prolonged stand of the glacier's front. Its surface varies from an almost smooth or gently undulating plain (Minooka Ridge) to typical rounded hills and saucer-shaped valleys with contained ponds or swamps. The last type is well seen on Mount Forest Island, as one walks south from Willow Springs, or in the hill territory about Palos Park. The hills and valleys are not so abrupt or so high as they are in the kettle-

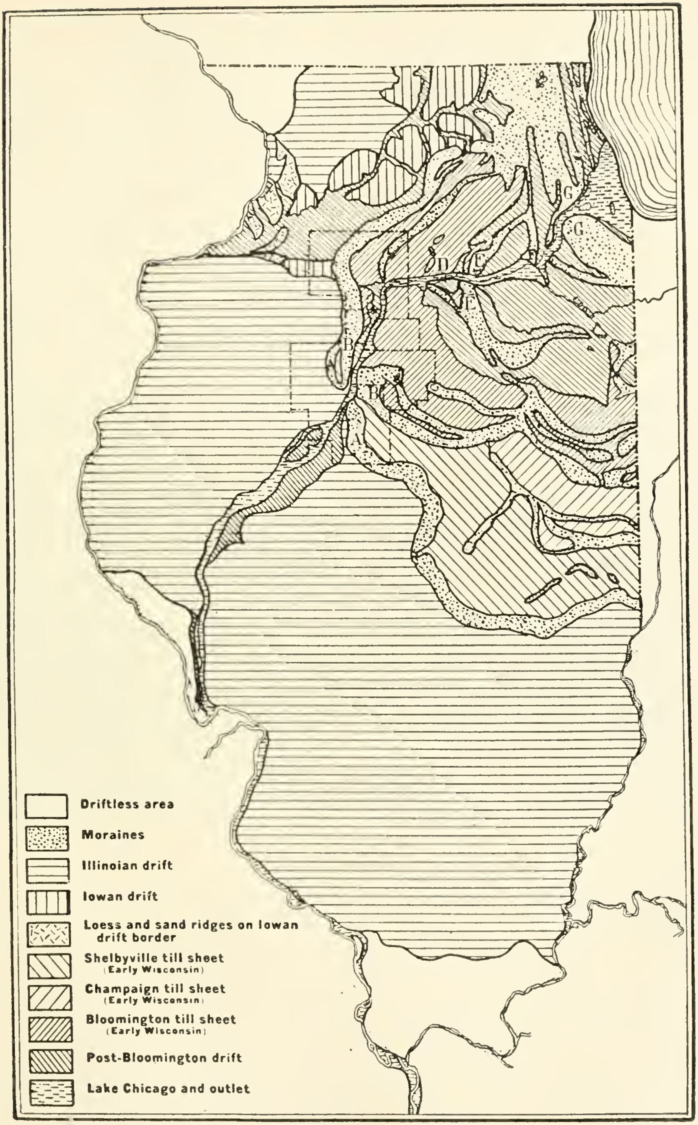

G
G
D
E
E
B
B
A
Driftless area
Moraines
Illinoian drift
Iowan drift
Loess and sand ridges on Iowan drift border
Shelbyville till sheet (Early Wisconsin)
Champaign till sheet (Early Wisconsin)
Bloomington till sheet (Early Wisconsin)
Post-Bloomington drift
Lake Chicago and outlet

FIG. 43.—Map of Illinois moraines. *Bulletin State Geological Survey*

moraine territory of southern Wisconsin about Cary, for instance; still it is very evidently moraine topography (Fig. 44).

The melting front of the glacier was pouring out torrents of water that discharged in a mighty river down a valley occupied now by the Desplaines, then the old preglacial valley and much deeper than the present one. The river discharged for a time, at least, into a lake that occupied the Morris Basin (see map), and this in turn had its outlet along the present Illinois Valley then also much deeper. This great river laid down material along its course, for it came away from the glacier so charged with sediment that wherever its current was checked in the least it deposited the gravel and sand. So it filled up its valley, and tributary streams filled up theirs with long-drawn-out deposits known as valley trains. It spread out a great fan-shaped delta at its entrance into the lake of the Morris Basin. The old valley was filled to a level some fifty feet above the present stream as is evident from the remnants of the old valley train still recognizable. "Opposite Lockport where the road to Plainfield leaves the valley floor" is a flat-topped gravelly ridge, a part of the old valley fill. Some four miles below Joliet there are flat-topped areas of gravel standing up conspicuously in the present valley,

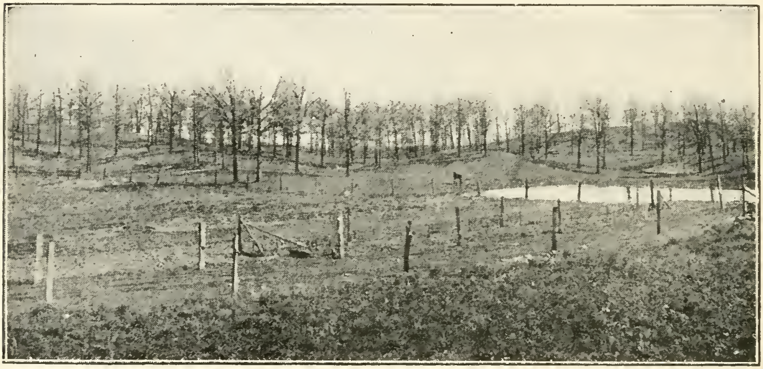


FIG. 44.—Typical moraine country, kettle-shaped hills and valleys, the latter often with ponds or lakes with no outlet.

generous remnants of the old valley train. The formation is known as "Flathead" (Fig. 45). At a level corresponding to its top on the north side of the valley may be seen a conspicuous shelf of similar gravel along which the upper road runs for some distance. These gravel deposits are rapidly being removed for commercial purposes.

Small streams rushing from points at the front of the glacier, charged with sediment, often deposited such material close to the glacier's edge as the current was checked when the stream spread out on to the open plain. Such mounds of débris, always irregularly stratified, are known as kames. Good examples of such are to be seen one and one-half miles northeast of Naperville, where the road to Wheaton passes between two dome-shaped hillocks, both kames. There is a large one east of Glen Ellyn, cut by the Aurora, Elgin and Chicago Electric Railroad. The east branch of the DuPage River is turned out of its southerly course by it.

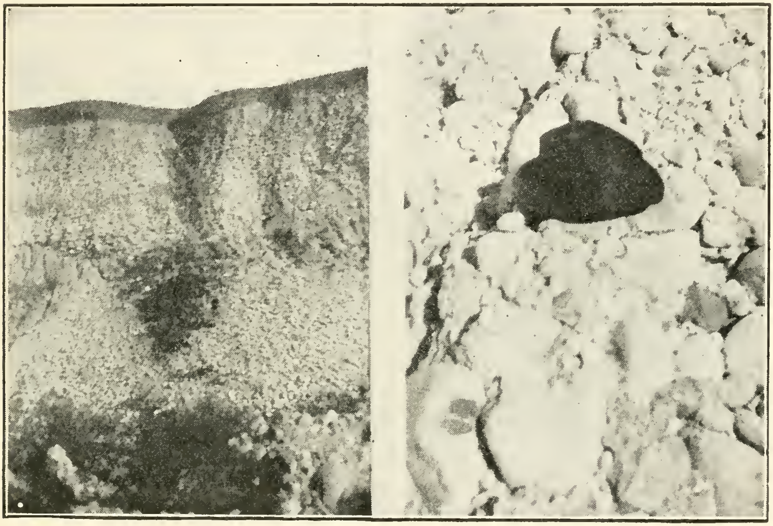


FIG. 45.—Flathead near Joliet. Detail at right, to show size of the gravel

In the southern portion of the glacier the warm sun melted the ice on its top as ice and snow melt in the early days of spring.

and the water, finding its way through cracks and crevices, flowed along in a stream underneath the glacier. Such streams often carried and then deposited material in elongated heaps of more or less stratified gravel and sand. Now that the ice is gone, these show as elongated hills known as eskers.

This glacial drift is made up of soil through which are scattered bowlders, small and large, or if the material is sorted by water, it is laid down in layers, coarse or fine according to the speed of the current that carried it to the present location. The bowlders and stones are subangular and more or less scratched and grooved. A large percentage of them are limestone, since the bed rock for a couple of hundred miles to the north is also limestone. But there are many samples of sandstone, quartzite, granite, gneiss, schist, diorite, diabase, and greenstone that have been brought into our region by the glacier from the ledges in northern Michigan and Canada where are located the nearest outcrops of these rocks in the direction from which the glacier came.

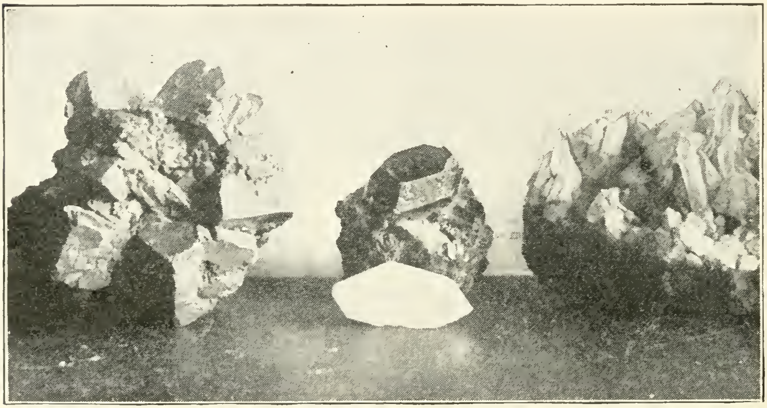


FIG. 46.—Crystals; at left cubes of galenite, at right quartz with a single quartz crystal in center foreground, in rear of it tourmaline crystal in matrix.

A rock is either a mass of some one mineral or made up of grains of several minerals. A mineral is a homogeneous inorganic substance of definite or nearly definite chemical composition, and it crystallizes into regular and constant form. Thus quartz, one of the most common of all minerals, is an oxide of silicon, SiO_2, with some water added if in crystalline form. The crystals are six-sided prisms with six-sided pyramids at each end, if perfect (Fig. 46). This mineral may occur in great masses or it may be merely one constituent of complex rocks. It is, for instance, an essential element in granite.

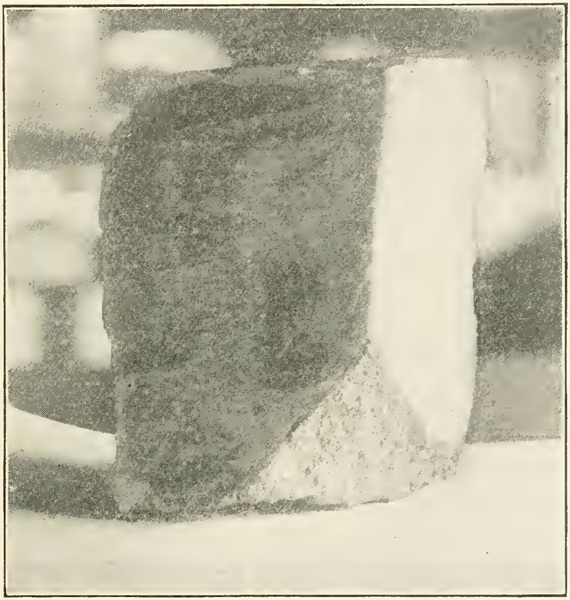


FIG. 47.—Piece of orthoclase feldspar showing cleavage

Not many minerals occur as conspicuous ingredients in the rocks of the Chicago region. It would be well to study these few in the collections to be found in the local museums like that of the Chicago Academy of Science or the Field Museum so as to be able to recognize them. Small collections may be had cheaply from any of the well-known dealers like Ward's Natural Science Establishment, Rochester, New York. The following tabulation will give the distinguishing characters of the commonly occurring minerals. A few terms need definition at the outset as they will be used in the descriptions. Certain minerals like calcite, galenite, and feldspar have a tendency to split easily along certain planes so that the pieces are bounded by smooth surfaces. This is known as *cleavage* (Fig. 47). Galenite cleaves into cubes, feldspar into blocks of which the opposite faces are parallel while the adjacent faces meet in angles that are either a little more or a little less than right angles. *Fracture* is the surface produced when a mineral breaks in any other direction than along its cleavage planes. Thus flint has a conchoidal or shell-shaped fracture. *Streak* is the color given when the mineral is rubbed on a piece of unglazed porcelain or when it is scratched. *Luster* is the appearance when light is reflected from the surface of the mineral. This may be vitreous like the reflection from a freshly broken piece of glass, resinous, pearly, silky, etc.—terms that carry their own meaning plainly. One of the chief means of distinguishing minerals is the *hardness*. So important is this that a definite scale of hardness has been agreed upon. Thus, talc has a hardness of 1, gypsum 2, calcite 3, fluorite 4, apatite 5, orthoclase 6, quartz 7, topaz 8, corundum 9, diamond 10. For ordinary purposes the hardness may be indicated in a less exact way, still the numbers given after each mineral indicated the hardness on this scale.

Sedimentary rocks.—As we have seen in the previous chapters, sedimentary rocks are originally laid down as beds (1) of calcareous materials like shells, corals, or their water-worn fragments, (2) beds of angular rock fragments, (3) of gravel, (4) of sand, (5) of clay, or (6) of plant débris. Later these, by means of cement, by pressure or by heat, acting singly or in unison, are transformed to stone. The calcareous material, really calcite or calcium carbonate, makes limestone a rock that can be scratched with a knife, effervesces with an acid, and often contains fossils. Angular rock fragments cemented together form a breccia, while if the fragments are waterworn, as gravel, the result is a pudding stone or conglomerate. The sand beds transform to sandstone and clay to shale, readily known by the ease of its separation into flakes. The plant material transforms into peat and coal.

So soft they can be scratched with the fingernail	Chalk, 0.5–2.5	White to gray, dull, crumbles in fingers, no earthy odor when breathed upon, effervesces with acid.
	Chlorite, 1.5–4.0	A green mineral of pearly to vitreous luster with greasy feeling. It usually occurs in grains or scales in basic rocks.
	Gypsum, 1.5–2.0	Many colors, streak always white. Massive (alabastine), fibrous (satin spar), foliated (if transparent called selenite).
Easily scratched with a knife	Kaolin, 0.5–2.5	Many colors, streak like color. Feels greasy. Strong clay odor when breathed on. Dull to pearly luster; brittle.
	Mica, 2.2–5.0	Perfect cleavage; very thin elastic scales can be obtained. The black sort is biotite; the colorless, gray, or pale green, muscovite.
	Galenite, 2.5	Lead gray, streak same. Metallic luster. Very heavy; cleaves in cubes.
	Serpentine, 2.5–4.0	Color, shades of green. Luster greasy, waxy, or earthy. Feels smooth or greasy. Compact and amorphous, making a rock of the same name.
	Calcite, 3	Many colors, streak white to gray. Always cleaves into rhombs. Effervesces in dilute acid.

Easily scratched with a knife (*continued*)	Sphalerite, 3.5–4.0 (Zinc blende)	Yellow, red, brown, black. Luster resinous when yellow. Perfect cleavage. Brittle.
	Chalcopyrite, 3.5–4.0 (Copper pyrite)	Brass yellow, often tarnished, then showing iridescence. Streak green-black. Softer than pyrite.
	Dolomite, 3.5–4.0 (Pearl spar)	White, gray, green, black. Streak white. Transparent to translucent. Crystals curved like saddles.
Scratched with a knife with difficulty	Mica, see above	
	Limonite, 5.0–5.5	Dark brown, streak yellowish brown. Often fibrous; if earthy, color is yellow. In cubical crystals.
Scratched by quartz but not with a knife	Pyroxene or Augite, 5–6	Green to black. Fracture uneven to conchoidal. Usually in short, thick, eight-sided prisms. Cleavage poor; faces meet at 90°.
	Amphibole or Hornblendes, 5–6	Brown, green, or black, darker than augite. Fracture as above. Luster pearly on cleavage faces. Crystals long, slender, six-sided, faces finely cross-striate. Cleavage faces meet at 124°.
	Hematite, 5.5–6.5	Cherry red to iron black; streak red. Metallic luster, massive or fibrous or scaly.
	Feldspar,* 6.0–6.5	Many colors, streak white. Cleavage perfect, faces at nearly right angles. Light colored, orthoclase; darker, plagioclase.
	Pyrite, 6.0–6.5 (Fool's gold)	Brass yellow, tarnishes brown. Streak greenish black. Metallic luster. Crystals, cubes or dodecahedra. Harder than chalcopyrite.

As hard as quartz	Olivine, 6.5–7.0	Green, streak white. Transparent to translucent. Usually occurs in rounded grains.
	Quartz, 7	Color anything from black to white. Luster vitreous or waxy in chalcedony. Fracture conchoidal. Crystals six-sided prisms ending in pyramids; blue, amethyst, banded agate, onyx, jasper. In massive nodules occurs as flint.

* The term feldspar stands for a group of minerals. Orthoclase is a silicate of aluminum and potassium—a "potash-feldspar." Its cleavage angle is a right angle, or nearly so. It is usually light in color, white, gray, pink. It commonly occurs in rocks in which quartz is present fairly abundantly and seldom associates with the plagioclase group. This plagioclase group includes the soda-lime feldspars like oligoclase and labradorite. The plagioclases have an oblique cleavage angle, and certain cleavage faces are marked with numerous fine parallel lines. The plagioclases, especially the oligoclase and the labradorite, are strongly basic, seldom occur with quartz in any quantity, often are present with augite or hornblendes. They are usually dark colored, blues, grays, or dull reds.

Igneous rocks.—Sedimentary rocks are largely formed from the disintegration of previously existing rocks. The original rock masses, together with many of those of later times, were formed from the cooling of molten material. Such are igneous rocks. When lava outpours on the earth's surface in volcanic regions it forms rock as it cools—volcanic rock. Such rock usually has a glassy appearance or, if it is crystalline, the crystals of which it is composed are small, usually indistinguishable, for it cools too rapidly to permit a thorough crystallization. Such volcanic rocks are liable to be quite porous on account of the bubbles of gas contained in the molten lava. The holes formed by the included bubbles of gas may later be filled by material deposited by percolating water. The grains of such deposited minerals are naturally rounded, and the rock so altered is known as an amygdaloid. Molten material, on the other hand, that cools off slowly way down below the surface makes coarse-grained rock, the crystals being large. Such rocks are called plutonic, in distinction to the volcanic. If one mineral is present in large crystals while the others are minutely crystallized or more or less glassy, the rock is called a porphyry. Plutonic rocks are dense, since formed below the surface under great pressure. Naturally there will be all intergrades between the plutonic and the volcanic rocks, since the cooling lava may be in any one of many situations from the deep-seated reservoir to the surface flow.

The molten material differs greatly in chemical composition in different regions of the earth and even two successive lava flows from the same volcanic crater may be quite unlike. If the lava contains much silica it is an acid lava and gives rise to rocks with many silicates and much free silica or quartz. If, on the other hand, it contains strong bases like calcium, magnesium, and iron, it is a basic lava and the resulting rocks will contain little free silica or quartz, though they will contain silicates of the basic elements mentioned in the form of such minerals as plagioclase, hornblende, augite, etc. The following scheme with the brief characterizations that follow will aid in the determination of the igneous rocks of the Chicago area. Nothing like a complete key or complete descriptions can be given here, and the interested student will secure some good lithology and study it in connection with the specimens of typical rocks found in the museums. This scheme will help the observer to make a start on interpreting the past history of a rock from its present structure. Five rock groups are given in the order of their increasing basidity so that, from left to right in the series, quartz is becoming less abundant, the rocks are darkening in color and increasing in weight as the plagioclases replace the orthoclase, and the augite, hornblende, and olivine at the end largely replace even the plagioclase.

Vertically in each column the members of any group are named from distinctly volcanic rocks down to those that are wholly plutonic. Going down the column, the members of the families are less porous, less glassy, the component crystals are constantly larger, and the rocks increase in specific gravity.

The granites contain quartz and orthoclase, often with some hornblende, mica, or augite. (The composition of the gneisses is the same, but they show evidences of stratification—see below.) If any one or two minerals are especially conspicuous, the granite is named accordingly, as hornblende granite, biotite-hornblende granite. If quartz is present in twin crystals in a matrix of feldspar, giving an appearance of cuneiform writing on a feldspar background, the granite is pegmatite.

Granite-Rhyolite Group	Syenite-Trachyte Group	Diorite-Andesite Group	Gabbro-Basalt Group	Peridote Group
Quartz and Orthoclase Dominant	Orthoclase Dominant: Quartz Absent or Present in Negligible Quantity	Plagioclase and Hornblende Dominant: the Latter Equaling or Exceeding the Feldspar in Amount	Feldspar (Labradorite) and Pyroxene Dominant: the Latter Equaling or Exceeding the Feldspar in Amount	Feldspar Absent or Nearly So: Hornblende, Pyroxene, Olivine, the Dominant Minerals
Rhyolite pumice (porous) Rhyolite obsidian (glassy)			Basalt tuff Basalt breccia	
	Trachyte (included in the felsites)	Andesite (included in the felsites)	Basalt dolerite Basalt	
Granite (crystalline) Other minerals may be present but not dominant giving biotite-granite, hornblende-granite, etc.	Syenite	Diorite	Diabase (Olivine diabase, olivine gabbro, green stone)	
			Gabbro	Peridotite
Porphyritic granite		Diorite porphyry	Diabase porphyry	
Pegmatite granite				

Syenite contains an abundance of orthoclase, usually the red varieties and little or no quartz. Hornblende, mica, and augite may any one or all be present. It is a plutonic rock and therefore usually coarse grained. The corresponding volcanic rock is trachyte, finer grained, more porous, and lighter in weight.

In the diorites the dark feldspars are predominant, though sometimes the lighter-colored plagioclases are abundant. Quartz is present and also often mica and hornblende but not in predominating quantities. The diorites are plutonic, the corresponding volcanic rocks being the andesites.

Gabbro and basalt are respectively the plutonic and the volcanic members of the next family. They are dark, heavy rocks with labradorite and augite as the predominant minerals. Biotite, chlorite, magnetite, pyrite, olivine, etc., may be accessory minerals. The gabbro is distinguished from the diabase by its coarser crystallization and the large quantity of pyroxene it contains. The presence of chlorite in these rocks gives them a distinct green color and they are then known as greenstones. It is difficult to distinguish the finely crystalline ingredients of trachyte and andesite in the field sufficiently to distinguish them, so they are usually called collectively "felsite" as distinguished from the darker and heavier basalt.

Metamorphic rocks.—Both sedimentary and igneous rocks may be altered by pressure, crumpling, heat, and other agencies, so that their original character is quite changed; such rocks are called metamorphic rocks. Thus the limestones become crystalline and transform to marbles, as do also the dolomites. The effervescence with acid still distinguishes them. Dolomitic marbles effervesce only in strong or hot acid, the ordinary marble in cold, even weak, acid. Sandstone is compacted, the sand grains fused to make quartzite—a rock that may have any color but can be distinguished by its hardness and conchoidal fracture. It is not as vitreous in luster as is quartz itself, and shows more or less its granular character. Shales are changed to slates, recognized by their easy separation into thin layers like roofing slate. Sedimentary rocks composed of the disintegration of granites are by metamorphosis altered to schists and gneiss. The latter contains the same minerals as granite, but there is evidence of stratification and the crystals or grains of the compressed minerals are arranged with their long axes in one plane. If the compression has been so great as to flatten the component grains or crystals into scales, the rock becomes a schist, easily broken down by the fingers, especially when it is somewhat weathered. Schists are commonly named from the mineral that is so predominant as to give them their chief character, as mica schist, chlorite schist, etc.

Granites seem also to have been transformed directly by metamorphic agencies into gneiss and the schists, so that the end result of metamorphism on such igneous rocks and on sedimentary rocks derived from them may be identical.

CHAPTER V

LAKE CHICAGO AND ITS OLD SHORE LINES

AS THE ice sheet finally melted (Fig. 48) and retreated farther north there formed between the Valparaiso Moraine and the front of the glacier a lake, called now Lake Chicago (Fig. 50). This had its outlet through the gap in the moraine known as the Sag. Two streams from the lake—one on the north, one on the south of Mount Forest Island (Fig. 53)—converged to this point. It was probably just chance inequalities of deposition that determined the location of these two channels, thus forming Mount Forest Island, but the Sag was likely predetermined by the fact that here ran the old preglacial valley, a deep rock cut, which though partly filled by glacial drift still made a distinct break in the restraining moraine. Besides Mount Forest Island another isolated mass of drift stood out of the water in the Chicago region, namely Blue Island. This now stands above the level of the Chicago plain, once the old lake bottom, as a ridge several miles long and one-half mile or so wide stretching north from the town of Blue Island to Beverly Hills. The Rock Island suburban line runs close to its east side. It is encountered as an abrupt rise on Western Avenue about Eighty-seventh Street. Anywhere along its crest one looks westward over level country, old lake bottom, to the distant hills of the mainland of the moraine or of the other islands.

Lake Chicago stood at one level for a long time, long enough for its waves to eat into the hills along its shores and deposit extensive beaches of sand just as Lake Michigan is doing now along its present shore line. The highest of these beaches stands at a level some sixty feet above the present lake level (581 feet above sea-level). It is by following these plainly marked beaches that the position of the shore lines of early Lake Chicago is determined (Fig. 49). On the map (Fig. 53, page 85), can be traced the shore line of what is known as the Glenwood stage of Lake Chicago (Fig. 50), so named because the beaches are particularly conspicuous at Glenwood near the Industrial School (Chicago & Eastern Illinois Railroad). Northwest from this point the old beach runs to the north of Homewood (on the Illinois Central Railroad) about a mile southwest of Rexford (on the Rock Island) to the north of Palos Springs (Wabash). It is plainly seen on the east side of Mount Forest Island (driving west on Ninety-fifth Street) or in approaching the island from Summit on the Chicago and Joliet interurban. At McCook

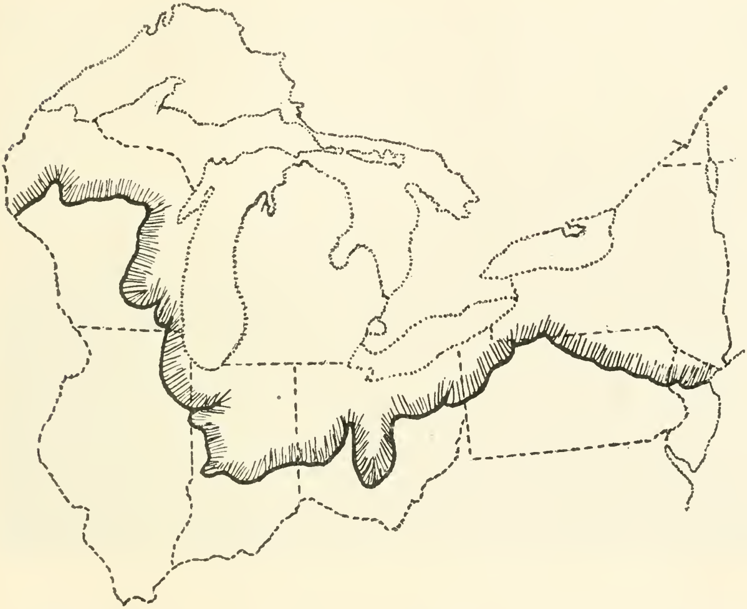


FIG. 48.—The Wisconsin ice sheet at its maximum. Border of ice represented by heavy feathered line.

(Atchison, Topeka & Santa Fe Railway) and to the north of La Grange (Chicago, Burlington & Quincy Railroad) it is particularly plain, marked by steep cliffs that have been more or less obscured by the later erosion and deposits. Galewood and Norwood Park are on it. Thence it runs northeast and terminates in the Chicago region at the present lake shore in high bluffs at Winnetka.

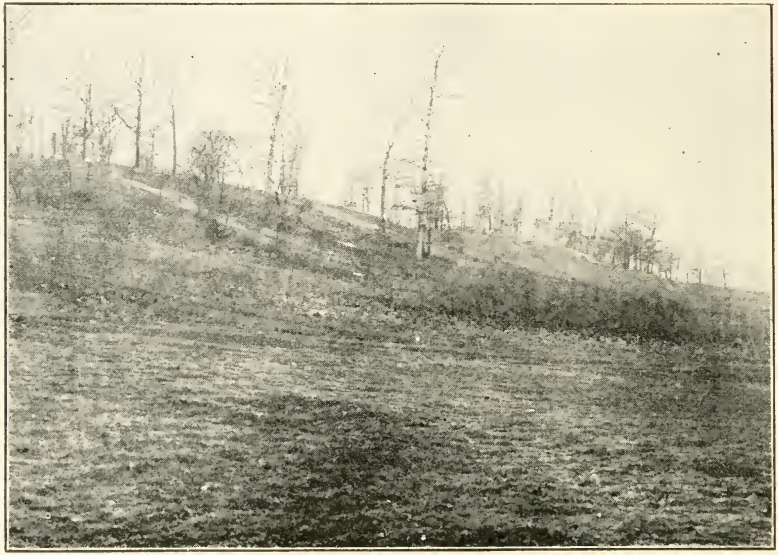


FIG. 49.—An old shore line of Lake Chicago

> In the northern part of Winnetka, a short distance south of the pumping station, the cliff and terrace of the Glenwood stage appear halfway up the lake cliff and extend inland with pronounced form for three-quarters of a mile. The terrace is about 55 feet above Lake Michigan . . . . behind it the bluff rises to a height of 20–30 feet, with a very steep slope.

To the east of Glenwood the shore line swings southeast toward the lake, passes through Furnessville, runs roughly parallel to the present shore, and abuts on the shore north of New Buffalo.

Notice Desplaines Bay on the map (Fig. 53), into which the river now bearing that name then emptied. See also the sand spit at the mouth of this bay and the spits at the ends of Blue Island. There was a great branching spit running south and west from a point below the present Winnetka reaching Niles Center, which spit then inclosed Skokie Bay and now forms the irregular eastern border of Skokie Marsh. The waters of the lake, moving toward the outlet or currents set up by the prevailing north winds checked by these projecting points, dropped their load of sediment in sand bars. The wash of the waves piled the material up above the lake level in these spits, just as they are formed along the lake shore today by the same agencies.

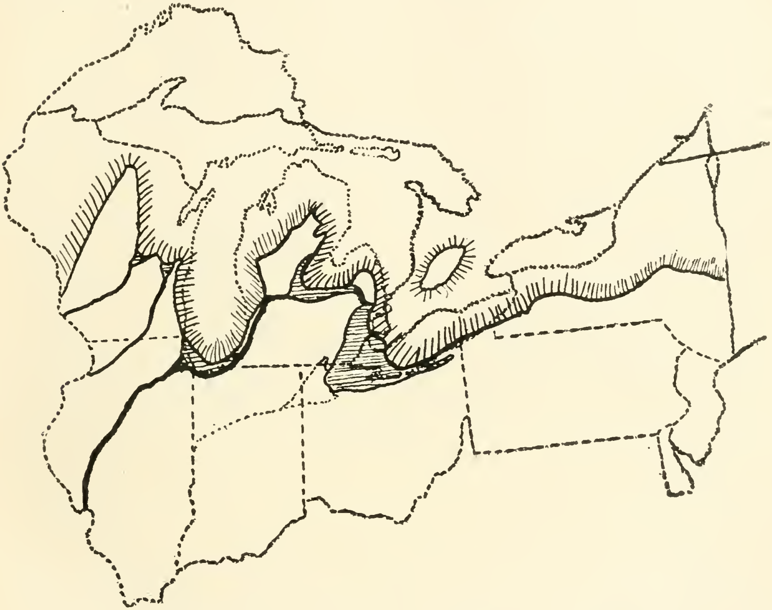


FIG. 50.—Lakes Chicago, Saginaw, and Maumee. Lake Maumee at an earlier stage was more extensive and outletted down the Wabash Valley as indicated by dotted lines. All three lakes now discharge through the Chicago outlet. This represents about the Glenwood stage of Lake Chicago. Modified from Leverett and Taylor.

Lake Chicago continued to grow in size as the front of the glacier retreated. But what is more important from our interest in its alteration of local topography, it changed its level, dropping so as to expose the bottom, hereabout, long enough for vegetation to become rank and form extensive peat deposits. This was probably due to the uncovering, by the retreat of the ice, of some outlet to the north, at a considerably lower level than the Chicago outlet. These peat beds are found in excavations such as some made in Rogers Park and Evanston several years ago, and they lie on the beaches of the Glenwood stage. They are overlaid, however, by deposits of the next or Calumet stage.

The lake rose again as possibly the glacier advanced temporarily and again covered the northern outlet. It assumed a level about twenty feet below the Glenwood stage, 35–40 feet above present level or 615–20 feet above sea-level. It again outletted down the Desplaines Valley. Undoubtedly during the Glenwood stage the valley had been deepened by river erosion. When the old river came directly from the front of the glacier before the lake was formed behind the Valparaiso Moraine, it was heavily charged with sediment and built up an extensive valley train as already described. But when the river became the outlet of the lake, the débris held by the glacier was dropped in the lake and the outflowing stream was clear, ready to pick up a load in its rapid current instead of making a deposit. So from the time Lake Chicago was formed the outletting stream had been working to erode and carry away the silt, sand, and gravel that it had earlier laid down. So the old valley formed by the preglacial stream that came down the broad valley where Lake Michigan lies and that continued down what is now the Desplaines and Illinois valleys was filled below the terminal moraines by the valley train deposited by the river that carried the outwash from the glacier and still later was again partly uncovered by the outlet of Lake Chicago.

This latter erosion was apparently checked in the upper valley when the river encountered a rocky ledge below the sand and gravel, a ledge running from the present location of Lockport to Joliet. This could not be worn away rapidly and so the level of the lake was held at this point for a long period. During this time the waves and currents made such inroads on the shore and such extensive deposits that we trace them today in a series of beaches and sand bars that are referred to this Calumet stage (Fig. 51). The course of the Calumet beach can be traced on the map (Fig. 53). The old Desplaines Bay was now dry land, and the river emptied into the lake near the present site of Lyons. Salt Creek flowed in at the same point. Evidently in the lake during the Glenwood stage a great sand bar had formed in the lea of Blue Island and a smaller one out in the south channel of the outlet. These now appear, the former as a portion of the large island that included Mount Forest Island and Blue Island, the latter as a separate islet, Lanes Island. Note the long sand

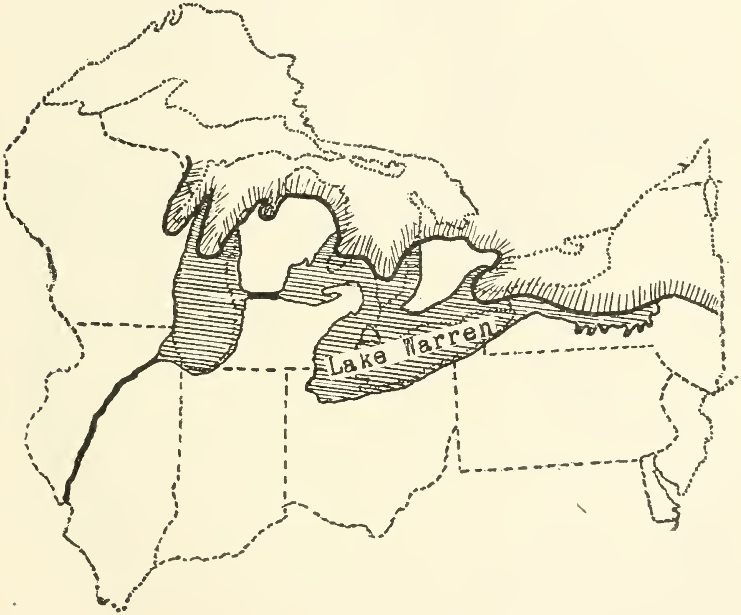


FIG. 51.—Lake Chicago at a later stage (the Calumet) and Lake Warren. A tremendous volume of water must have been going through the outlet past the present site of Chicago. After Leverett and Taylor.

spit thrust out from the north end of the large island, its elbow at what is now Summit, sheltering a big bay then probably an extensive marsh.

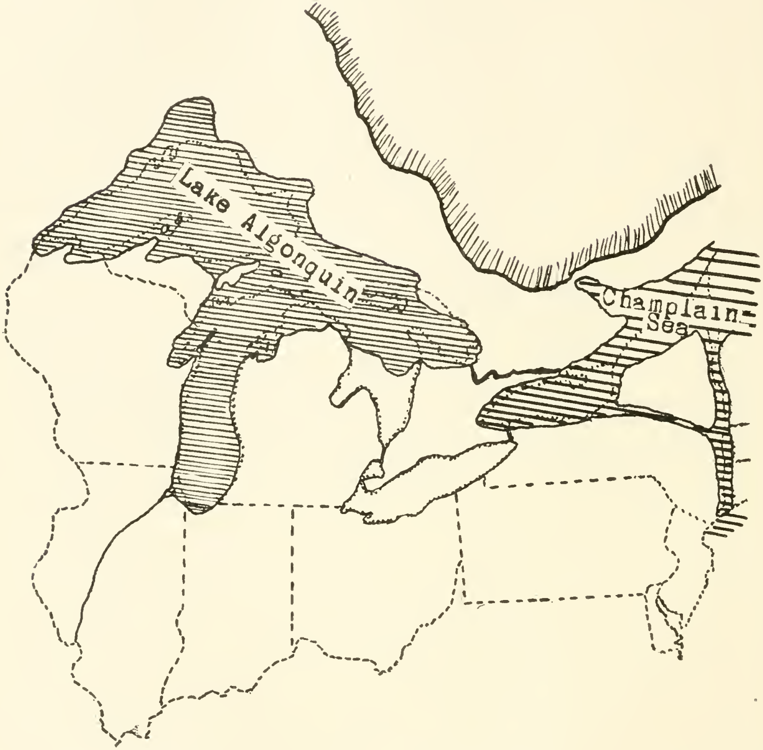


FIG. 52.—Lake Algonquin; some water was still going out of the Chicago outlet but most of it discharged down the Trent River Valley to Champlain Sea. Note also the Hudson and Mohawk estuaries. This represents about the Tolleston stage. After Leverett and Taylor.

Jefferson Park, Cragin, Riverside, Summit, Washington Heights, Oaklawn, Dalton, Thornton, etc., are all on the old Calumet beach. Eastward it follows closely the Glenwood shore line to which it is roughly parallel. There was a great offshore bar built up at this stage. This now terminates near Rose Hill

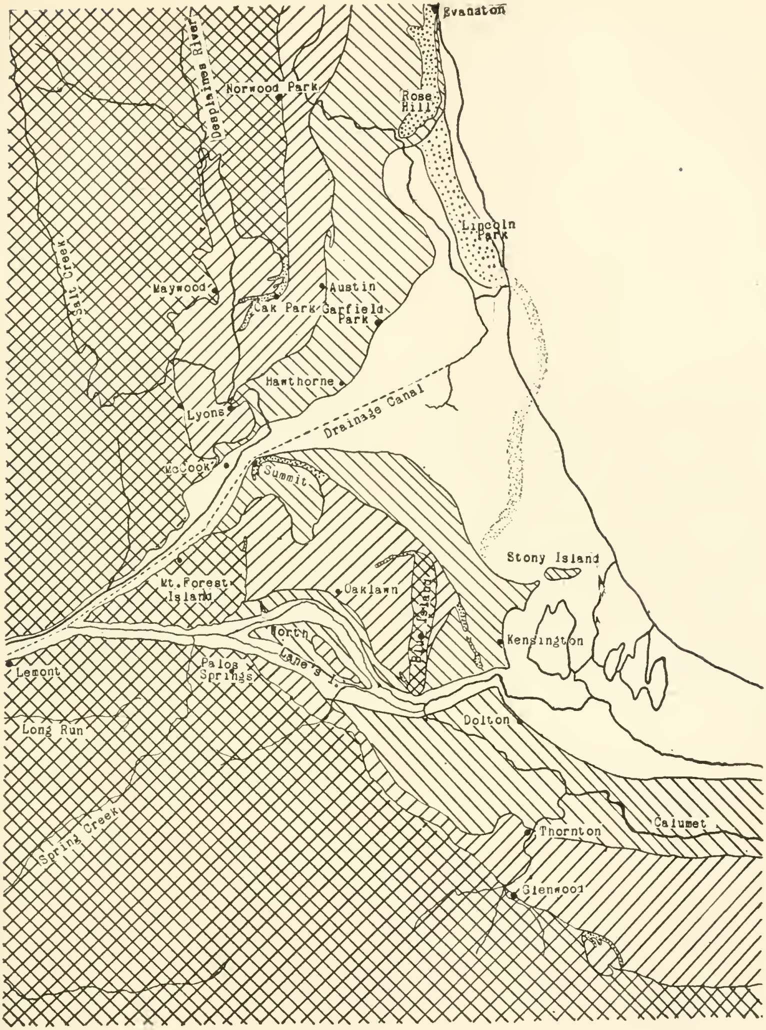

Evanston
Desplaines River
Norwood Park
Rose Hill
Lincoln Park
Salt Creek
Maywood
Austin
Oak Park
Garfield Park
Hawthorne
Lyons
Drainage Canal
McCook
Summit
Stony Island
Mt. Forest Island
Oaklawn
Blue Island
Kensington
North
Lane's I.
Lemont
Palos Springs
Dolton
Long Run
Calumet
Thornton
Spring Creek
Glenwood

Fig. 53.—Map of the Chicago plain and adjacent moraine.

×××
××× Land bordering Lake Chicago at the Glenwood stage.

/// Added land as the lake dropped to the Calumet stage.

\\\ Land added by drop to Tolleston stage.

Land added by drop to present level in white.

Sand bars dotted.

Cemetery and it is named the Rose Hill Bar. It runs north and east through Rogers Park and Evanston, where for six miles it is followed by "Ridge Avenue." It rises some twenty feet above the surrounding plain. The outlet to the north of Mount Forest Island was apparently partially blocked, possibly by the Summit sand spit and the others that were formed offshore, so that at this Calumet stage the main outflow was through the present Lake Calumet region, past the south end of Blue Island along the outlet to the south of Mount Forest Island. The great potholes in the bedrock here, uncovered in the construction of the Calumet branch of the Drainage Canal, worn by rocks in the grip of eddies, indicate a large and rapid river (Fig. 54).

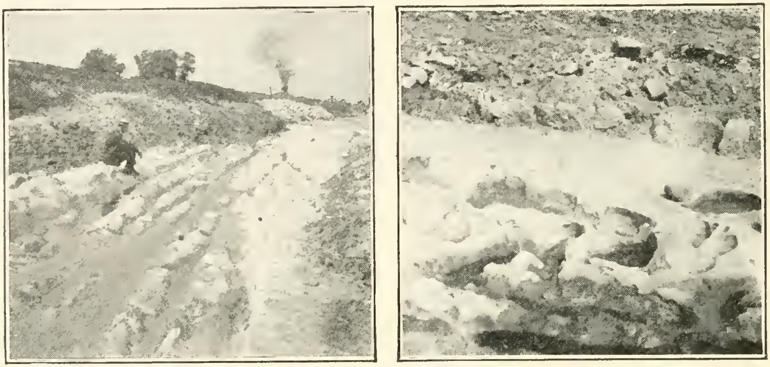


FIG. 54.—When the outlet of Lake Chicago was chiefly to the south of Mount Forest Island the swift river current, carrying rocks, wore grooves and potholes in the limestone bed. They are seen here where excavations for the new canal freshly expose the bed rock.

The rock barrier in the bed of the outletting river at Lockport which held the lake at the Calumet level could not stop the lowering of the valley floor indefinitely. The obstruction was made up of the inclined strata of Niagara limestone against which, near Joliet, lay much softer shale. The river had no difficulty in cutting away these shales, but the limestone was a more difficult proposition. However, the limestone strata were so inclined that the river rushed down the incline, which was at the downstream end of the obstruction, forming a rapids with violent current that worked furiously at cutting out the rock. Gradually the rapids ate their way through these strata until finally they reached the upper end of the rock dam. The rock barrier once removed, the stream rapidly cut through the gravel of the old valley train to the lake and another drop in the lake level occurred, of some fifteen feet. A reference to the map (Fig. 51) will show that through the Chicago outlet was flowing, during the Calumet stage, not only the waters from the front of the Michigan lobe, but also that from much of the Saginaw and Erie lobes. This great stream was undoubtedly a vigorous worker.

So Lake Chicago assumed a new level, the Tolleston stage (Fig. 52), some twenty feet above present lake level or about six hundred above sea-level. It held it long enough to cut a new shore line and deposit extensive beaches. The location of these Tolleston beaches is shown on the map (Fig. 53).

The main Tolleston beach abuts on the lake shore not far north of the campus of Northwestern University which it crosses from North Gate, running inland beneath Herck and University Halls. It runs through the city on the east side of Chicago Avenue and in South Evanston is followed pretty closely by Clark Street. Thence it continues south of Calvary Cemetery, through Rogers Park and Rose Hill, bordering the old Rose Hill Bar. From Garfield Park to Hawthorne it is very plain. It is easily traced east from Summit, thence southeast through Auburn Park and Burnside. Stony Island, an island new born at this Tolleston stage of the lake, appears here close offshore, and the Tolleston beach is very plain on its northern side. From Burnside the beach runs south through Kensington, then swings east and follows quite closely the general present contour of Lake Michigan.

It will be noted that both north and south outlets on either side of Mount Forest Island are pretty well closed by the end of this stage, for a great sand spit had been built all across the north outlet, a natural embankment later used by railroads entering Chicago from the east. The Desplaines no longer emptied into the lake but was flowing south through the channel of the old outlet. Below the main Tolleston beach are one or two others showing apparently considerable fluctuation at this stage. It is thought that Lake Chicago had become a part of the greater Lake Algonquin, which included Lakes Superior, Michigan, Huron, and more (Fig. 52). It was discharging through Lake Erie. Probably some of these Tolleston beaches were the shore lines of this greater lake. There is evidence that the level of the water in the lakes dropped considerably below its present level when for awhile the great lakes discharged through Georgian Bay, the river Trent across Ontario to an arm of the sea in northern New York (Champlain Sea) (Fig. 52). But finally through a gradual rise in these northern areas the level of the water rose to the present grade, and the discharge through Lakes Huron and Erie was resumed.

It is interesting to note how human affairs are determined by events that transpired hundreds of thousands of years ago, long before man had even appeared on the earth. The route followed by two great transcontinental railroads in entering Chicago—the Chicago & Alton Railroad and the Atchison, Topeka & Santa Fe Railway—is that of the old outlet of Lake Chicago, and its location was determined by the presence of the preglacial valley whose position was fixed by the lay of the rock strata deposited in Paleozoic time. The same thing is true elsewhere. The Lackawanna and the New York Central, in leaving New York City for the West, follow the valleys of old rivers that carried the main outwash from the glacier, and their location was fixed by the lay of rock strata that were deposited aeons ago. Lake Michigan, Desplaines River, and the Illinois River were made a great north and south artery of travel when the old preglacial valley continued past the present site of Chicago down what later became the Illinois Valley. And when the Valparaiso Moraine happened to so deposit that the portage from the Chicago River to the Desplaines was fixed within the present city limits, Chicago's site was practically settled. Even the locations of our fashionable residence sections, streets, railroad approaches, recreation parks, and sewage system were more or less completely settled by the deposits of moraines, locations of old beach lines, sand spits, and dunes of the old glacial lake.

CHAPTER VI

DISTRIBUTION AND ADJUSTMENT

THE purpose of this and the succeeding chapters is to show how the physiographic features of the Chicago region, the origin of which has been outlined in the preceding pages, determine the distribution of plants and animals, not directly but by shaping in large measure the interplay of those factors that do condition the plant and animal life. The chief factors for plants are available moisture and light; for animals, the oxygen supply, food, nest-forming materials, light, heat, currents, foes, etc. Furthermore, plants and animals are nicely adjusted in structural peculiarities and habits to the complex of these limiting factors, and it will be the aim of succeeding pages to point out also some of these adjustments.

It is a matter of common knowledge that, the world over, there is a zonation of life. The vegetation of the tropics is totally unlike that of the temperate regions, and the life of the latter zones is quite different from that of the arctic. The ascent of a mountain carries the traveler through a succession of life-zones, from the luxuriant growth about the base through scant vegetation and disappearing animals to a bleak and almost uninhabited peak.

Temperature is on the whole a very great factor in the determination of the abundance and character of both plant and animal forms. Locally its effect is to settle the distribution in time rather than fix the place in which animal or plant shall grow, for naturally there is no very great difference in temperature in the various parts of the Chicago area unless it be a contrast between the deeper parts of lakes and their surface waters. But there is a seasonal distribution of both plants and

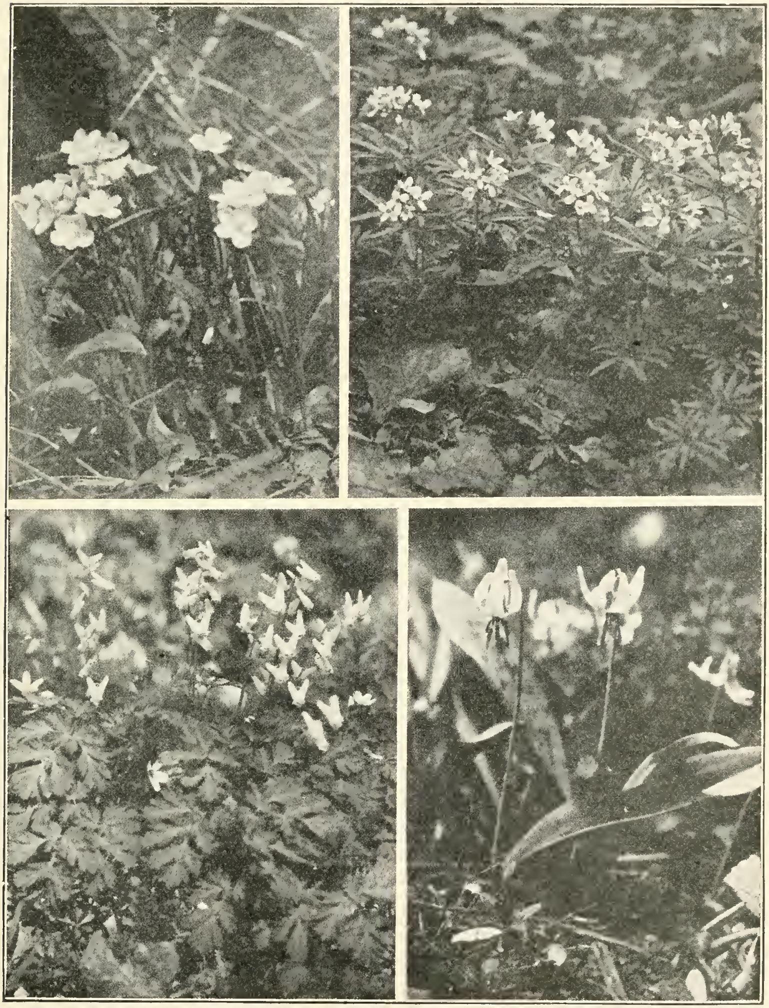


FIG. 55.—Spring flowers of the forest floor: Upper left, spring beauty, *Claytonia virginica;* upper right, toothwort, *Dentaria laciniata;* lower left, Dutchman's-breeches, *Dicentra cucullaria;* lower right, yellow adder's-tongue, *Erythronium americanum.*

animals locally. Thus we have a distinct spring flora. Note, for instance, the early annuals of the oak woods—spring beauties, anemone, toothwort, trillium, hepatica, Dutchman's-breeches, dogtooth violet, bloodroot—these and others like them are all plants that are up and in blossom before the trees are in leaf to shade them (Fig. 55). They get through with their life-cycle—bud and flower and fruit—here on the forest floor while the great trees overhead are just beginning to stir with the thrill of the spring awakening. These plants have found an unoccupied part of the season, and they make the best of it. They all possess underground stems loaded with stored food that enable them to make this very rapid growth, then slowly accumulate during months of shade a supply sufficient for the next spring. Moreover, in many cases their tender leaves that appear while frosts are still common are clothed in dense hair—a veritable fur coat to protect them. They are replaced later by other plants that have become adjusted to growing in the dense shade of the summer under the trees. Those mentioned need abundant sunlight to carry through their brief program of rapid maturation.

The temporary grassy ponds that result from the melting of the snows are the homes of a group of animals that appear marvelously indifferent to the low temperatures of early spring; they thrive in the ice-rimmed water. There is the so-called fairy shrimp, *Eubranchipus* (Fig. 56*d*), not a shrimp at all, though its airy grace and mysterious appearance make the rest of the name appropriate enough. It is a reddish-brown crustacean, a quarter of an inch long when first seen, but growing rapidly to an inch in length. It swims on its back, waving nineteen pairs of feathery legs to propel itself. The head bears a pair of staring compound eyes. The egg sacks of the females are conspicuous early, and strings of slender eggs can be seen in the semi-transparent body on their way to be discharged into the icy water. The adults soon die; the whole life-history occupies only a month or so of early spring. The eggs lie dormant in

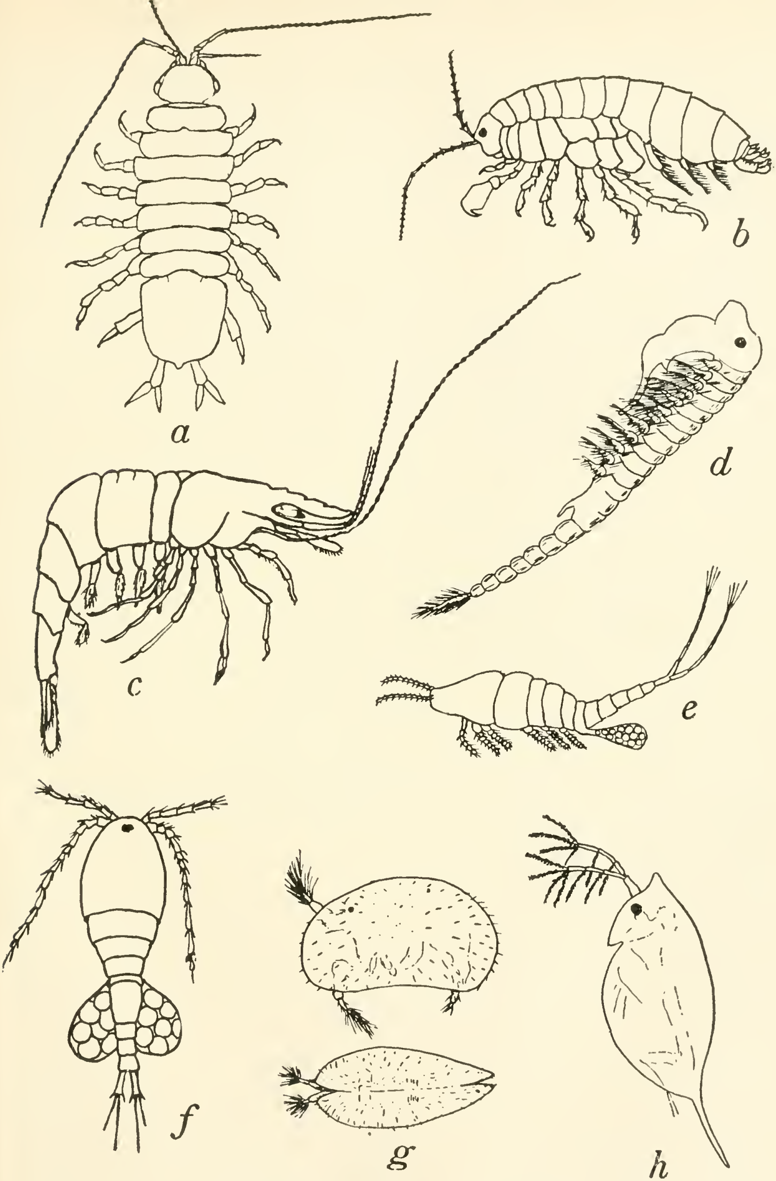


FIG. 56.—Some fresh-water crustaceans *a*, *Asellus*, the water sow bug; *b*, *Gammarus*, the bender; *c*, *Palaemonetes*, the true shrimp; *d*, *Eubranchipus*, the fairy shrimp; *e*, *Canthocampus; f*, *Cyclops; g*, *Cypris*, side and top views; *h*, *Daphnia*, the water flea.

the bottom of the pond. When it dries up they dry, too. They may blow about in the wind to new locations. They freeze with the winter cold; in fact they will not hatch until they have dried out and frozen. And so they are ready to start the next generation in the ponds of the following spring.

Other inhabitants of these ponds are the red water mite, *Hydrachna*; a tiny crustacean with a bivalve shell, looking like a very small clam until it sticks out its feathery swimming organs (*Cypris marginata*) (Fig. 56*g*); the water sow bug (Fig. 56*a*); the bender (Fig. 56*b*), a crustacean that swims rapidly with even speed, but which when taken in the hand bends and unbends rapidly; *Cyclops, Daphnia* (Fig. 56 *f, h*); some cladocerans; the green flat worm. Here, too, one may find, if low prairie is near, the spring peeper, *Chorophilus nigritus*, that marsh tree frog whose clear peep is almost like a bird note. It takes to the ponds to lay its eggs almost before the ice is gone. The eggs are laid in gelatinous clusters that fill the palm of the hand and in the pond are attached to the grasses along the margins or to sticks in the shallow places.

The frog's egg is admirably adapted to hatch on these cold days. It is covered with a transparent jelly layer that retains the sun's heat like the glass of a greenhouse. It has a black upper surface that absorbs heat like a black dress. The egg is laid so early that it avoids many of the insect larvae that would later prey upon it. It is inconspicuous, its black upper surface harmonizing well with the dark pond bottom when seen from above, and its light under surface with the clouds when seen from below, so that it easily escapes detection.

Just as there are an early spring flora in the woods and a spring fauna in the temporary ponds, so there are early spring plants and animals in the swamps, on the dunes and in other typical localities. In each place the spring types are followed by early summer types, by midsummer and autumnal species. One need only call attention to this seasonal distribution to have it substantiated by many commonplace facts. Thus we name many insects by the time of their appearance, as May flies, June beetles, the fall army worm, etc. Just as the appearance of the robins and the bluebirds marks early spring, so we think of midsummer as butterfly time, and the chirp of the cricket as the first voice of fall.

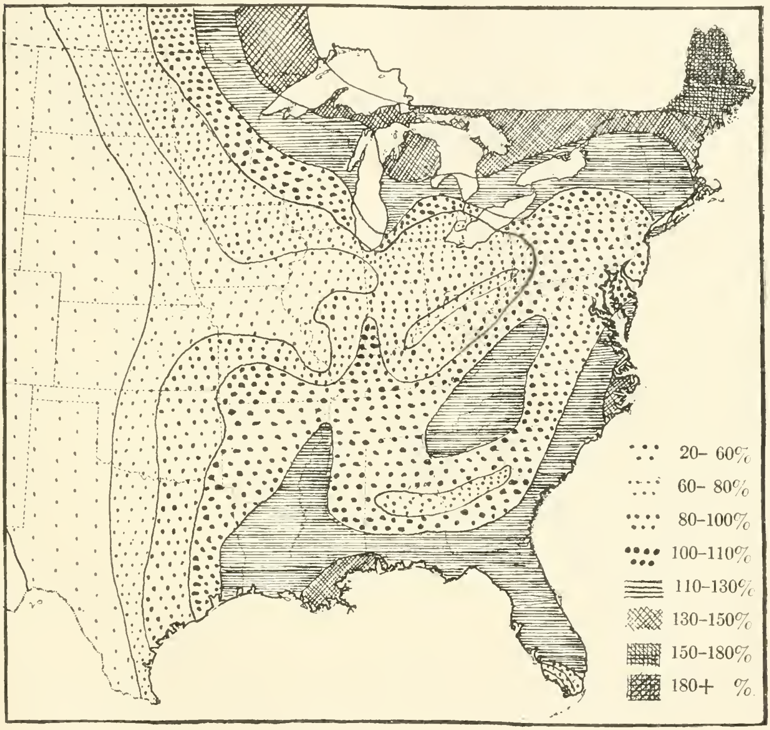


FIG. 57.—Map showing relation of rainfall to evaporation in Eastern United States. Unmarked lower left, rainfall 20 per cent or less of the evaporation. The other markings are explained on the figure.

In the local place distribution of plants, moisture is of prime importance, or rather the ratio between rainfall and evaporation. If the water supply greatly exceeds the evaporation, then the plant grows in a pond or marsh and is designated a hydrophyte.

At the other extreme are the xerophytes, plants growing where the evaporation tends greatly to exceed the water supply. The open dunes give an excellent illustration of such conditions.

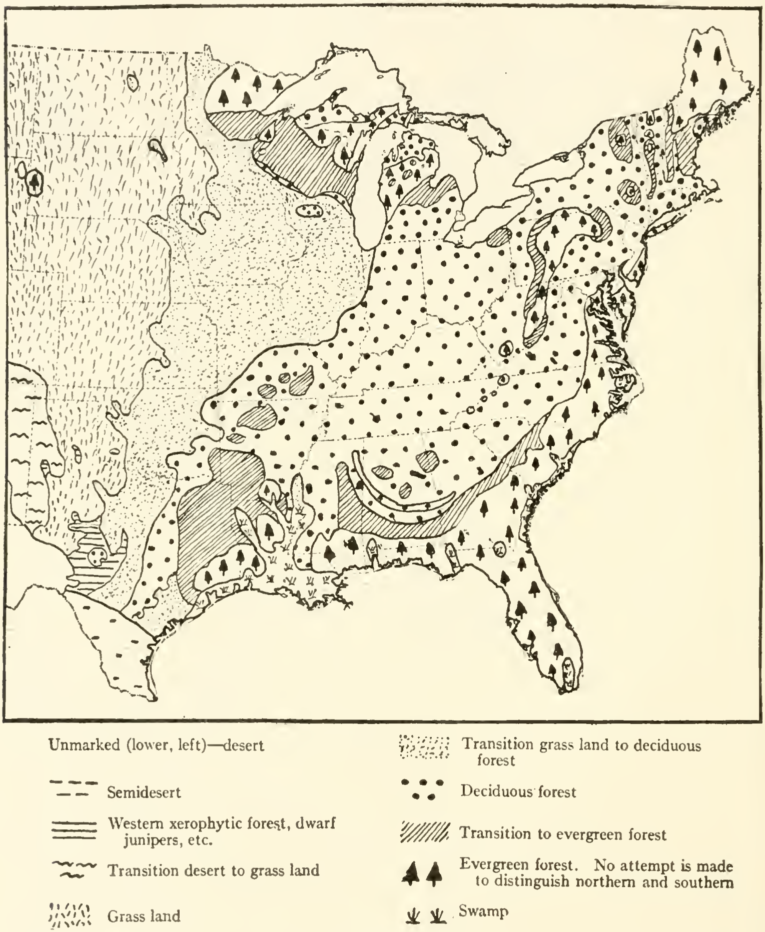

Unmarked (lower, left)—desert
Semidesert
Western xerophytic forest, dwarf junipers, etc.
Transition desert to grass land
Grass land
Transition grass land to deciduous forest
Deciduous forest
Transition to evergreen forest
Evergreen forest. No attempt is made to distinguish northern and southern
Swamp

FIG. 58.—Map of vegetation areas in Eastern United States. After Shreve

The great majority of plants grow where there is neither excess nor dearth of water and are known as mesophytes. This ratio of evaporation to rainfall is a very important factor in determining plant distribution on a large scale as well as locally. This is apparent from a comparison of the accompanying maps, one (Fig. 57) showing the ratio of rainfall to evaporation in the various parts of the United States, the other (Fig. 58) the forest, prairie, and plains areas. The general coincidence of forest distribution and of the areas occupied by prairies and plains with the areas of a decreasing rainfall is very striking.

That physiographic features must affect the moisture content of the soil is evident on reflection. A poorly drained area develops swamps, bogs, and wet prairie. A rock surface is prone to be xerophytic; so too will be the steep side of a clay bluff. On the other hand, the side of a rock ravine may furnish hydrophytic conditions, for the sunlight penetrates so little that the temperature is low, the evaporation is slight, and even though water be not abundant, it may be so well conserved as to be adequate to moisture-loving plants. The accompanying diagram (Fig. 59), modified from Adams, will show how great differences there are in rate of evaporation in contiguous regions, and also that temperature differences, while not great, may still be sufficient to influence animal and plant distribution.

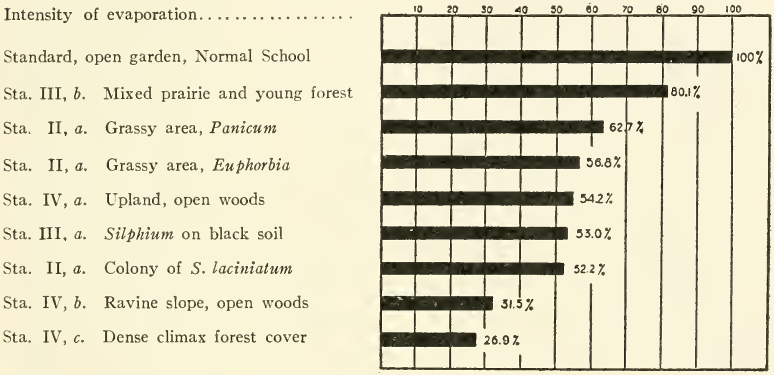


FIG. 59.—Diagram of the relative evaporation in different prairie and forest habitats, showing the great reduction in evaporation with the development of a *closed* forest canopy of a climax forest; Charleston, Illinois. After Adams.

Many marked structural peculiarities and adaptive life-habits go along with the ability of the plant to endure drought or excessive moisture. Since the loss of water goes on largely through the leaves, the leaf surface of the xerophyte is often reduced in proportion to its volume by the leaf being needle shaped rather than flat and thin. The leaf surface may be covered with hairs, and so evaporation becomes reduced, or the surface may be covered with impervious wax; such a weed as the mullein, growing in open waste territory, is a familiar example of the former, and the glossy-leaved plants of the ground stratum in the pine dunes—like the wintergreen, shinleaf, and prince's pine—are examples of the latter, as is also the very common field milkweed. The oak leaf and that of the cottonwood are both thicker and glossier than the leaf of the hard maple or beech that grows in the mesophytic conditions of the climax forest. The leaf stem or underground portions of the

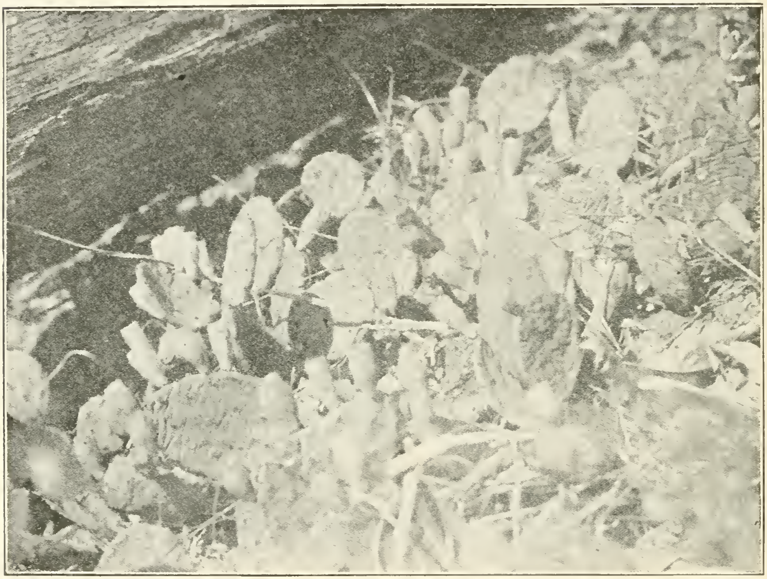


FIG. 60.—The cactus, *Opuntia Rafinesquii*, in fruit in the dunes

plant may be thick and succulent, storing up water in time of plenty to use in time of drought. The common cactus of the dunes is a good illustration (Fig. 60). The plants growing where moisture is lacking often develop an extensive superficial root system to gather up the dew and the showers before the water has time to dissipate or sink deep into the parched soil. One can pull out fine stringlike roots in the open dunes that run just below the surface for hundreds of feet to the tree or bunch grass.

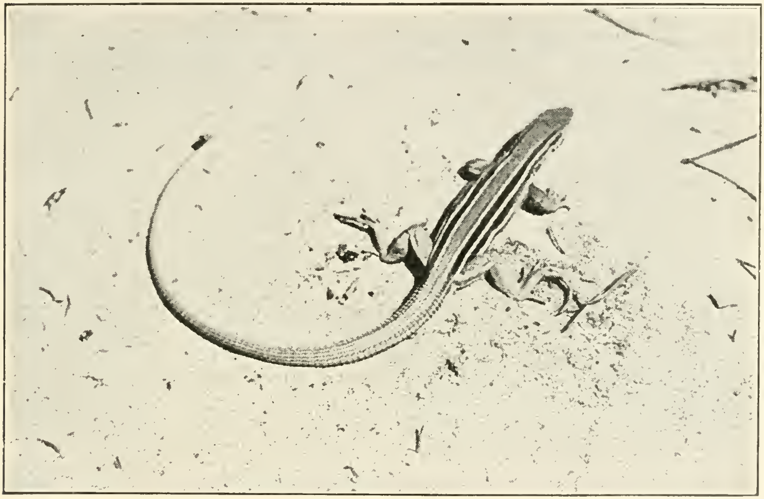


FIG. 61.—The six-lined lizard, *Cnemidophorus sexlineatus*

Many of the animals of the open dunes are in hiding during the day, some of them like the burrowing spider, *Lycosa wrightii*, in holes that run down to the cool and moist soil layers. The surface of the sand is covered in the early morning with the fresh tracks of many animals that have been out during the cool of the night to satisfy their needs, while the same areas are apparently uninhabited by day. The six-lined lizard (Fig. 61), that like the cactus is a desert form left in this sandy oasis by the lake, excretes its uric acid in solid form, a conservation of water common to many reptiles.

The light relation determines not so much where the plant grows as its habits of growth in a locality fixed chiefly by the water supply. Thus, some plants are said to be shade loving. They are found forming the ground stratum in the forest with other plants, a shrub stratum, over them, plants less able to endure the shade, though they in turn are overgrown by a tree stratum whose members insist on getting up into the full glare of the sunlight (see Fig. 297). The entire association is due to the mesophytic conditions that all need, and probably the stratification is due quite as much to the relative amounts of evaporation (see Fig. 62) as to the varying light intensity. How dim the light is in the ground layers of the forest becomes apparent in trying to take pictures in the beech-maple woods; the exposure meter indicates an intensity one-twentieth that of the surrounding open pastures; so undoubtedly the light factor is to be regarded as of great importance. This is made more evident when the fact is recognized that the same shade-loving plants found on the forest floor are also often found in the rock ravine. Thus, the clearweed, the touch-me-not, and such characteristic ferns as the beech fern, the fragile fern, and the spleenwort, *Asplenium angustifolium*, are common in both locations (Figs. 270, 273, 274, 395).

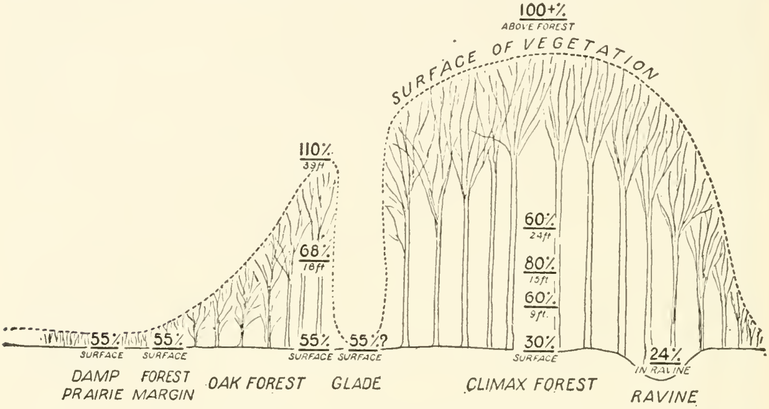

100+%
ABOVE FOREST
SURFACE OF VEGETATION
110%
39ft
68%
18ft
60%
24ft
80%
15ft
60%
9ft.
55%
SURFACE
55%
SURFACE
55%
SURFACE
55%?
SURFACE
30%
SURFACE
24%
IN RAVINE
DAMP PRAIRIE
FOREST MARGIN
OAK FOREST
GLADE
CLIMAX FOREST
RAVINE

FIG. 62.—Diagram showing relative evaporating power of air as influenced by prairie and forest vegetation. After Adams.

Some plants growing in the intense light of the marsh and prairie have very interesting habit adaptations that avoid the intense light and heat of midday. The upright position of the leaf in the grasses, the iris, and cat-tails accomplishes this, for the edge or tip of the leaf is presented to the midday glare, the broadside of the leaf catching the less intense early morning or late afternoon sun. The common lettuce (Fig. 63) and the compass plant, *Silphium laciniatum*, both have the habit of turning their leaves so that they are in a vertical position at noon, the tips north and south, one edge up, the other down, so showing the edge rather than the broad side to the noon light.

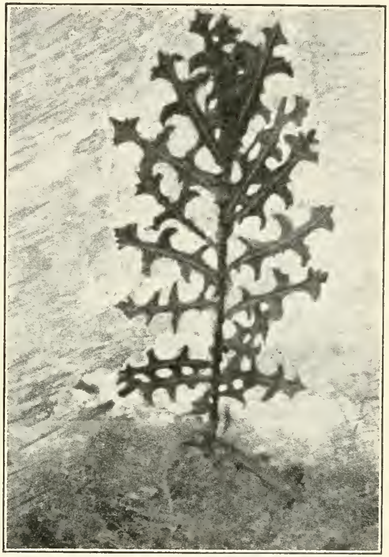


Fig. 63.—A compass plant, wild lettuce, *Lacluca scariola.*

No single line of demarcation in the distribution of animals is as clear cut as that between the water animals—the water breathers as they are commonly called—and the air breathers. Of course in each case the oxygen in the air is the important element taken, but in the water forms this is absorbed from the supply dissolved in the water, while the others take it directly in the respired air. Probably in the course of evolution most animal as well as plant life was aquatic in its origin. The hydrophyte and the hydrozooid are the primitive types, and these early forms lived not only where water was abundant but they lived under water. Such an existence necessitates on the part of complex forms some special device for taking the needed oxygen, for every living thing must have this essential gas since it is only by constant oxidation that the energy supply is maintained, by means of which all live and move and have their being. The simple plants and animals can absorb the oxygen and give off the carbon dioxide, together with other waste products of combustion, directly through the moist skin. But the higher types have needed to develop gills or similar structures and some sort of circulation to take the gas to the working cells. The more complex plants growing totally submerged have their leaves dissected so that they consist of numerous threadlike filaments or else they are long and narrow, ribbon-like, so that every part of the leaf is near the oxygen supply of the water. See, for instance, the leaf of water milfoil, of bladderwort, of hornwort, all common to our ponds or streams (Fig. 64). The water buttercup at times grows submerged, again only partly so. The submerged portions have leaves that are finely dissected, the aerial portions the usual buttercup leaf. It is interesting to note that the animal gill is built on the same general plan as the submerged leaf, a series of filaments, sometimes branched. In the animal these are provided with vessels that take up the needed oxygen and carry it to the distant internal organs.

The transition from water-inhabiting animal to land dweller is seen in the life-history of our common toad. The eggs are laid in the water, hatch into tadpoles that are vegetarians, and breathe by means of gills. In time these develop legs, resorb their tails, come out on to the land, replacing the gills by lungs and feeding entirely on insect food. When the first sea worms crawled out of the water to make their burrows on land, a wealth of food was awaiting them in their virgin hunting ground, for the land was largely unoccupied by animal life. When some primitive fish crawled out on the mud banks, using its fins as legs—and there is one that does this still—it was rewarded by a lot of food which others of its kind could not get. But soon the earth swarmed with life, and even the air supported a full complement. Then, apparently some of the animals that earlier forsook the water for the land or air went back again to hunt in the water, and no more interesting series of adaptations is to

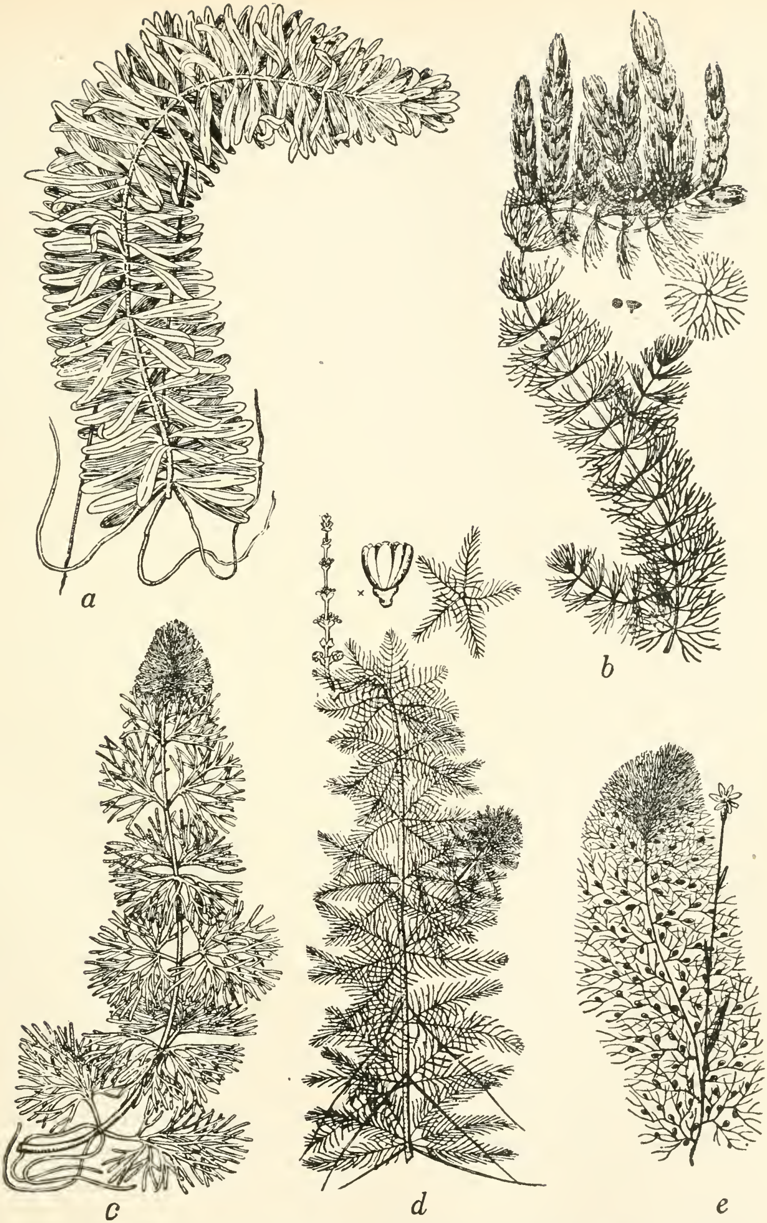


FIG. 64.—Leaves of water plants: *a*, *Anacharis;* *b*, *Ceratophyllum* or hornwort; *c*, *Caboma* or water moss; *d*, *Myriophyllum* or milfoil; *e*, *Utricularia*, or bladderwort.

be found than those enabling the land animals to live in the water. Insects likely evolved from land forms and never did live in the water until some of them took to it as a secondary consideration. They are primarily air breathers, taking the air in through numerous spiracles on the sides of the body to a system of internal, ramifying air tubes. When they took to the water they were forced to strange devices. Some diving beetles like *Dytiscus* and some of the *Hemiptera* like the giant water bug carry down a supply of air between the concave back of the abdominal portion and the overlying convex wing covers. The spiracles or breathing pores, which on most insects are on the sides of the abdomen, are now on its top, which is the bottom of the air chamber. Other animals enmesh enough air in the hairs of body and legs to last them awhile; they seem to carry a film of silver over the parts, the air film reflects so much light. The common water scorpion has a long air tube at the posterior end of the body so it can stand submerged on some aquatic plant and still breathe through its air tube, the open tip of which is kept at the surface (Fig. 212).

Even the spiders have taken to the water. Some common locally walk on the water and count it no miracle, they even run with celerity, capturing flies and gnats out of the reach of their less fortunate kind. One, the diving spider, hunts under water, even spins its silken nest below the surface. This nest is cup shaped, the opening down, and the adult spider carries down to the eggs and young a supply of air enmeshed in the hair of abdomen and legs that it scrapes off so as to keep the cup full until the young are old enough to come to the surface for their own supply (Fig. 213).

Some insect larvae are also air breathers and must come to the surface to renew their supply. Such, fortunately for us, are the mosquito larvae that we may exterminate by oiling the ponds and ditches where they breed, so they cannot get to the top. Such, as also the adult insects already described, are really air breathers. But there is a host of insect larvae that are true water breathers, taking in the oxygen by means of gills. These may be platelike structures, as in the damsel-fly nymph, or they may be filamentous, as in the larvae of stone fly, May fly, or whirligig beetle (Fig. 212). In the nymph of the common dragon fly respiration is accomplished through the wall of the large intestine, and a special chamber for the purpose is attached to this organ, the water flowing into it through the anal opening.

Snails, clams, and fish have largely remained water breathers, as have also most of the crustaceans. Some of the latter like the land sow bug have taken to damp situations on land, as under old logs and under the bark of stumps. The common chimney crayfishes live much of the time out of the water near the tops of their burrows, still breathing however by gills (see Fig. 379). Many snails have come to be land dwellers, always in damp situations, though, but still they breathe by means of a lung as do even some of the pond forms. Locally we have no fish that live out of the water, but there are such that run around on the mud banks or even climb logs and inclined tree trunks in search of insects; and in some—the African lung fish, for example—respiration is accomplished in the air by means of the modified swim bladder, an organ that in most fish is a float, but that serves in this one the purpose of a primitive lung.

We do have examples in abundance of the higher vertebrates that have taken to the water as a hunting ground and must modify their air breathing to suit the exigencies of the case. The frogs, turtles, some snakes, such birds as the grebes, and mammals like the muskrat are cases in point. The muskrat has ring muscles about its nostrils by the contraction of which he can close these openings when he dives. The bones of grebes have spongy interiors as indeed do those of all birds. The lung cavities connect with these porous portions so the air-supply that can be taken below water is increased. The frog spends its winter entirely submerged, hibernating in the mud at the bottom of the pond. Its mouth and nostrils are then closed air tight and what respiration goes on is accomplished through the skin, a return to the primitive method.

The amount of oxygen contained in the water plays a very important part in determining the distribution of the water-breathing species. Some can live only where there is an abundance of it. Thus, some sorts of insect larvae, snails, and fish are found only in the rapids of the brook where the constant turmoil of the water brings in an abundant oxygen supply; such will not live at all in the nearby quieter reaches. Other kinds, on the contrary, can get on very well even in the stagnant pools where the decomposing organic débris is abundant, the oxygen content low, and the carbon dioxide content high. The details of such distribution will be considered in a later chapter on the brook community.

Another exceedingly important factor in determining the distribution of animals, probably the most important locally, is the location of the food supply. Thus one sort of animal may feed on a single species of plant or those of one genus, and then its distribution is determined by that of its food plant. *Anosia plexippus*, the monarch butterfly, is found the world over only where the milkweed grows. This is not only because the butterfly feeds upon its blossoms, by no means exclusively, however, but because the young feed on the leaves. Similarly the young of the anglewing butterflies are reared on violet leaves and locally they are abundant along the borders of wood or on moist prairies where the violet abounds. One hunts for the pawpaw butterfly, *Papilio ajax*, and for the spicebrush swallowtail, *Papilio troilus*, only in the climax forest, though of course occasionally one may wander some distance from its customary habitat. This mobility of animal life as contrasted with the fixity of most plants makes it more difficult to fix the limits of animal associations; and yet, making due allowance for the wanderer, they are quite as definite. So important is the food plant that one could almost name animal communities after the plants that serve as centers of attraction, either directly as a food or indirectly by harboring animals that are the prey of the carnivorous types. The common milkweed has such a host of visitors—nearly four hundred, though not all in any one locality—that the group may be collectively called the milkweed association. So we may speak of the corn plant association, a group of plants and animals that directly affect the crop and so assume large practical significance. Such a grouping of animals would, of course, make as many societies as there are food plants, a multiplication of detail that fortunately is obviated by the fact that plants are grouped into societies by the interplay of certain factors, so that the animals, as far as the food factor is concerned, tend to a like grouping. This will appear in detail in the succeeding chapters.

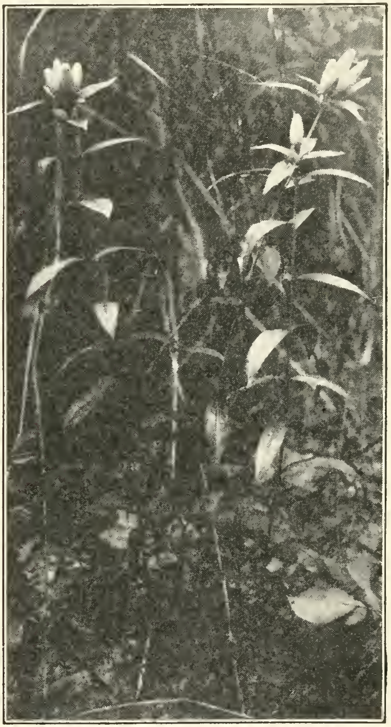


FIG. 65.—The closed gentian, *Gentiana Andrewsii.*

This relation of a specific animal to a particular plant as its source of food is the foundation of some of the most remarkable adaptations to be found in nature. The nectar of the flowers, much sought by insect epicures, is available only to a favored few. Thus the common weeds, butter and eggs and the closed gentian (Fig. 65), both bear blossoms that shut with so firm a spring that only the strong and heavy bumblebee can force an entrance. He pays for their hospitality by carrying the pollen so essential to flower fertilization and seed production. A rosin weed common on the prairie, *Silphium perfoliatum*, bears water cups, ensheathing the stem, formed by the bases of the leaves (Fig. 66). These effectually keep crawling insects away from the blossoms so the nectar may be reserved for the flying forms that alone serve the plant in pollination. The wild pink accomplishes the same object by rings of sticky substance exuded on its stem at the nodes. Flowers with long tubular corollas like evening primrose, trumpet vine, and Jimson weed are so deep that only insects with long sucking tubes like the moths and butterflies can reach the nectar, though sometimes the bumblebee bites through the base of the blossom and steals a meal. The hound's tongue, whose blossom is the color of aging meat and which has a corresponding odor, is visited chiefly by flies that seem particularly adapted to enjoy its sweets and to transfer its pollen. Sometimes a flower is so constructed as to require the presence of a single sort of insect to take out and carry its pollen; such is the case with the Yucca, grown as an ornamental plant in our gardens and dependent on the yucca moth that is always associated with it.

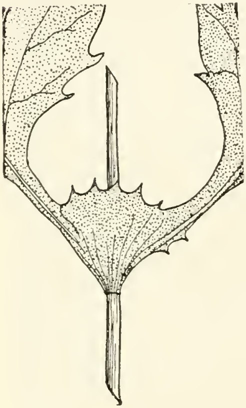


Fig. 66.—Cup formed about the stem at base of leaf petioles, *Silphium perfoliatum*, the cup plant.

On the blossom clusters of a fall aster with white-ray flowers and yellow-disk flowers one often finds a spider that has a yellow body and white legs. Lying thus concealed by its harmonious coloring, it pounces on the visiting flies and so secures its food.

There is a plant louse or aphid that feeds on the roots of our common field corn. It in turn furnishes to the common brown ant a fluid excretion that serves as food and seems to be highly prized. The ant takes the eggs of the aphid into its burrows in the fall, rears the aphids, and in the spring sets them out to feed on the tender shoots of weeds until such time as the corn germinates, when they are transferred by the ants to the corn roots.

Light is an important factor in the distribution of animals. Thus many species inhabiting the ground, the subterranean fauna, are repelled by strong light. Such is the case with the earthworm. An electric flash light will reveal in the garden or forest at night many earthworms, their anterior ends projecting from the burrows in search of decayed leaves, their chief article of diet. The bright light causes their instant withdrawal. The sow bug, woods cockroach, bark beetles, wood borers, slugs, and many spiders prefer the dark or the dim light and are to be found by day only in their retreats under bark or stones or in similar situations.

There is a whole host of water forms that, while minute, are the chief source of fish food. They are so sensitive to light that they migrate from the deeper waters to the surface and back again as the light wanes or brightens. There are protozoa, rotifers, and many tiny crustaceans in this association, together with a variety of microscopic plants on which they feed. Altogether this assemblage of living things, a floating or free swimming population, is known as plankton. In Turkey Lake, Indiana, at the time of its maximum, it constitutes more than one-half per cent by volume of the water; in Lake Michigan scarcely a thousandth as much. Such a density as that in Turkey Lake means more than fifty million organisms to the quart. Kofoid found in the Illinois River at the State Biological Station about five millions per quart, a million of which were animals. Since tiny fish feed on these organisms they follow the plankton in its diurnal migration, and the larger fish that are carnivorous go along too. Any fisherman knows that trolling for bass is best in the early morning or late afternoon, and that luck is better on a cloudy day than a bright one. The plankton and the small fry are near the surface in the dim light, and so, too, are the big fellows that feed upon them and that may by mistake try the fisherman's lure.

Nesting sites and nest-building materials are factors that help to determine animal distribution. The muskrat and his northern relative, the beaver, are found along the streams, not alone because his food is here abundant, but also because the material for the house is here. The cliff swallow prefers natural rock walls beside the water to which to affix his mud jugs for nesting purposes. The woodpecker must live in the forest, not only because his food is there, but also because he needs a tree for his nest site. The marsh wren away from the marsh would probably find it more difficult to find substitute for the rushes she uses to make her globular nest (see Fig. 345) than she would to secure her insect food. Shelford found that, giving the tiger beetle, which is found on the clay bluffs along the shore, opportunity in the laboratory to deposit eggs on steeply inclined and level clay, sand, and loam, in all cases the females chose the clay in which to deposit the eggs and that two-thirds of the holes made in oviposition appeared on the *steep* clay.

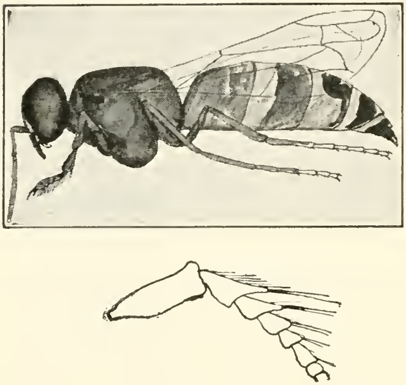
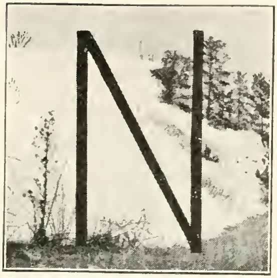


Fig. 67.—Digger wasp of the Dunes, *Bembex spinolae*, ×4. Below, the front foot, ×10.

Complex adaptations, both of structure and of habit, have arisen in connection with the use of specific locations or of particular materials in nest building. A single instance must here suffice. In the cottonwood zone in the Dunes there is a digger wasp that excavates a burrow in the sand in which to deposit its eggs (Fig. 67). The wasp is a little larger than a house fly. It stands on the sand to dig, and proceeds very much like a dog digging a hole in the ground. It uses the forefeet as excavating tools and throws the dirt out from under its body between the hind legs. It makes the dirt fly, too, at a great rate. The animal's front foot is expanded and provided with bristles along the edge that further enlarge it and make quite an efficient digging tool. The burrow usually starts on a sloping hillside and runs in, inclining downward from the mouth. It is three or four inches long. In digging it the wasp cannot throw the sand out from the far end at once, but must move it several times, about an inch each time, by the method already described. While digging she comes to the mouth of the burrow frequently, backing out always, stands still a moment, and goes back to work unless some inadvertent movement of the observer scares her, when she flies away to return shortly if all is quiet. The burrow completed, the mouth is closed, the wasp throwing the earth into it from all sides, changing her position repeatedly to do this. Then she flies off to secure insects with which to stock her excavation. She apparently uses dead flies chiefly, which she secures from the dead insects washed up by the waves along shore. On her return with a fly she drops it on the sand near the nest site. She runs around erratically to locate the hole exactly, uncovers the opening, quickly seizes the fly, and goes in with it. She reappears almost immediately, covers the opening, and flies off for another. When four or five flies are secured she remains in the burrow somewhat longer with the last, emerges backward as usual, and then spends considerable time closing the opening and pawing the sand about until all trace of her work is obliterated. Presumably the egg or eggs are laid in the burrow, possibly on the flies that are to serve as food for the growing grubs. The most remarkable thing in this whole story is that when, after many days, the young female emerges from her gravelike nursery she shortly proceeds to dig a hole, stock it with flies, lay the eggs, and cover up the nest with consummate skill, yet she has received no instruction, has not even seen the job done. Somehow in her nervous system is registered the racial instinct, and she goes through the whole performance unerringly, untaught.

CHAPTER VII

THE DUNES AND THEIR PLANTS



NO REGION about Chicago manifests such rapid changes in physiographic features as the dune region, and nowhere are the effects of these changes more apparent on the distribution of plants and animals. It is, therefore, a very favorable region for an initial study of plant and animal societies.

It extends from Gary east along the shore of the lake and well up the eastern shore. The area is from a quarter of a mile to several miles in width and with occasional interruptions where clay bluffs come to the shore it is a hundred miles or so long. In general it consists of a succession of sandy ridges that are roughly parallel to the lake. These vary in height; the crests of the tallest stand 200 feet above the level of the lake. Those nearest the shore are quite barren, but those farther back are increasingly covered with trees and associated shrubs and herbs. Between these steep-sided hills are valleys occupied often with long narrow ponds or with marshes and swales (see chap. ix).

The effective storm winds in the Chicago region come out of the northwest. These pile up the waves that erode the shores and heap the sand upon the beaches. After a heavy storm a newly formed sand bar offshore is a common sight (Fig. 68). Since the shores of Lake Michigan lie north and south, the effect of these furious winds is to tear down the lateral shores by wave action and drive the débris by currents gradually southward. Ultimately this débris will be pulverized by the waves, deposited in bars, and thrown up in sandy beaches on the east side and the south end of the lake. These same stiff winds pick up this sand after it has dried out on the shore, and carry it inland. So the winds that blow vigorously inshore are sand laden, ready to scour with the vigor of a sandblast but also ready to deposit wherever their velocity is checked.

Clumps of growing plants are the most effective agencies in checking the wind and causing deposition. Wherever the bunch grass is growing, or where a grapevine or a low juniper spreads its interlaced branches on the surface of the sand, there the sand-laden air driving into the mass of vegetation is checked and so deposits some of its burden before it escapes (Fig. 69). But such sand heaps are small. The interlaced stems and branches of young trees and shrubs make the most successful device for enmeshing the sand and forcing the wind to deposit it in larger dunes. A clump of red-osier dogwood or a thick stand of cottonwoods are buried quite rapidly, and did they not grow

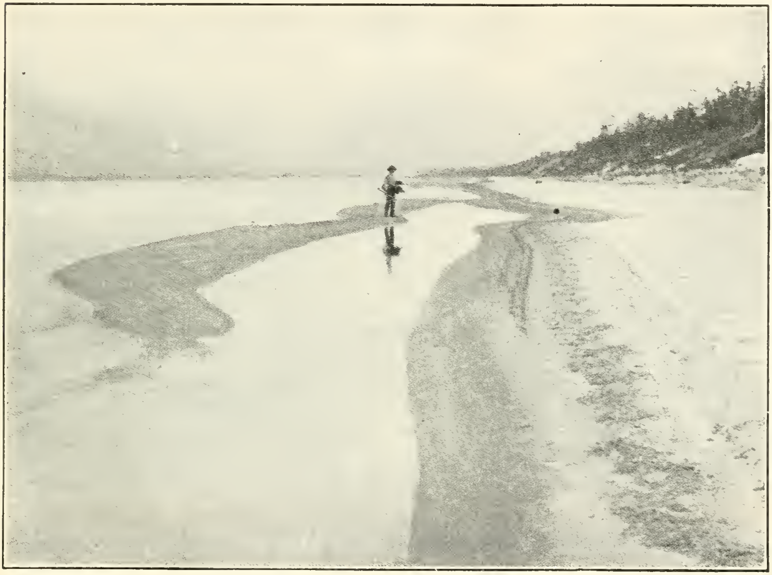


Fig. 68.—A newly formed sand bar

more rapidly than the sand piles up, they would be completely engulfed by the drifting sand.

A dune, therefore, usually starts on some low-lying area near the shore where the sand is sufficiently moist to allow many cottonwood seeds to germinate, yet far enough from the storm beach so the seedlings are not uprooted by the heavy waves. Such a low, moist germination bed is known as a panne (Fig. 70). That cottonwoods are the predominant growth in such a locality is due to the fact that these poplars are the commonest trees in the neighborhood, as will be explained shortly, and also because their seeds are small, tufted with a silky pappus that insures their ready transportation by the wind. Other plants that might take kindly to such a place, like the red-osier dogwood, have seeds that are not wind-blown. A wagon crossed a low area near the lake west of Mineral Springs in the spring of 1912. The ruts left in the moist sand facilitated the lodgment of poplar seeds, and the next year a double row of seedlings was found and photographed on the spot (Fig. 71). In two years' time a dune was forming, as is seen from the photograph of the same spot in 1915. In fact, in that time the sand had piled up somewhat over two feet, and now it is shoulder-high.

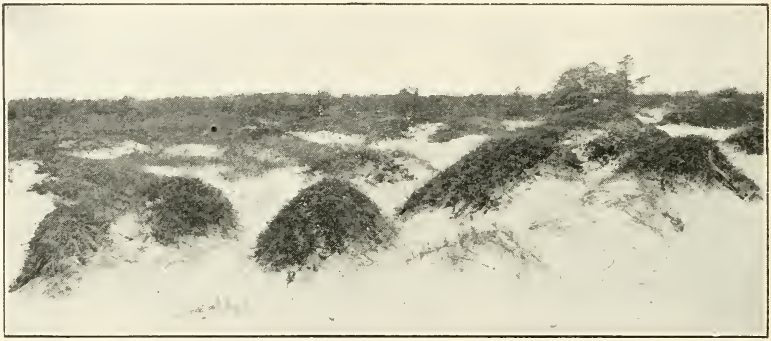


FIG. 69.—Small dunes held by bunch grass and prostrate juniper, *Juniperus horizontalis*.

We shall have occasion to remark constantly in the succeeding chapters on the adaptation of particular plants and animals to specific environmental conditions. Indeed it is to be the major purpose of the remainder of the book, to show how plants and animals are grouped in societies that are determined by the ability of the several organisms to endure similar conditions. In the dune region the associations are roughly parallel to the shore and for plants succeed each other in the following order: (1) the beach association; (2) the fore-dune association; (3) the cottonwood association; (4) the pine association; (5) the black oak association; (6) the mixed oak association; (7) the oak-hickory association; (8) the maple-beech association.

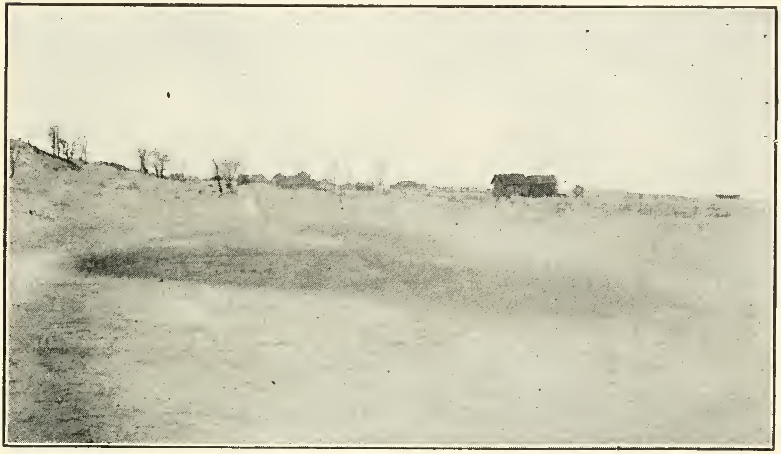


FIG. 70.—A panne near Miller, Indiana

Along the border of the lake is the wave-swept beach, where no living thing can maintain permanent residence. Even here there are transients among the animals as will be explained shortly. There is a stretch of wind-blown, shifting sand, the storm beach pounded by breakers raised by the heavy winds; this also is nearly barren of life. A few annuals grow here during the summer when severe storms rarely occur. The sea rocket

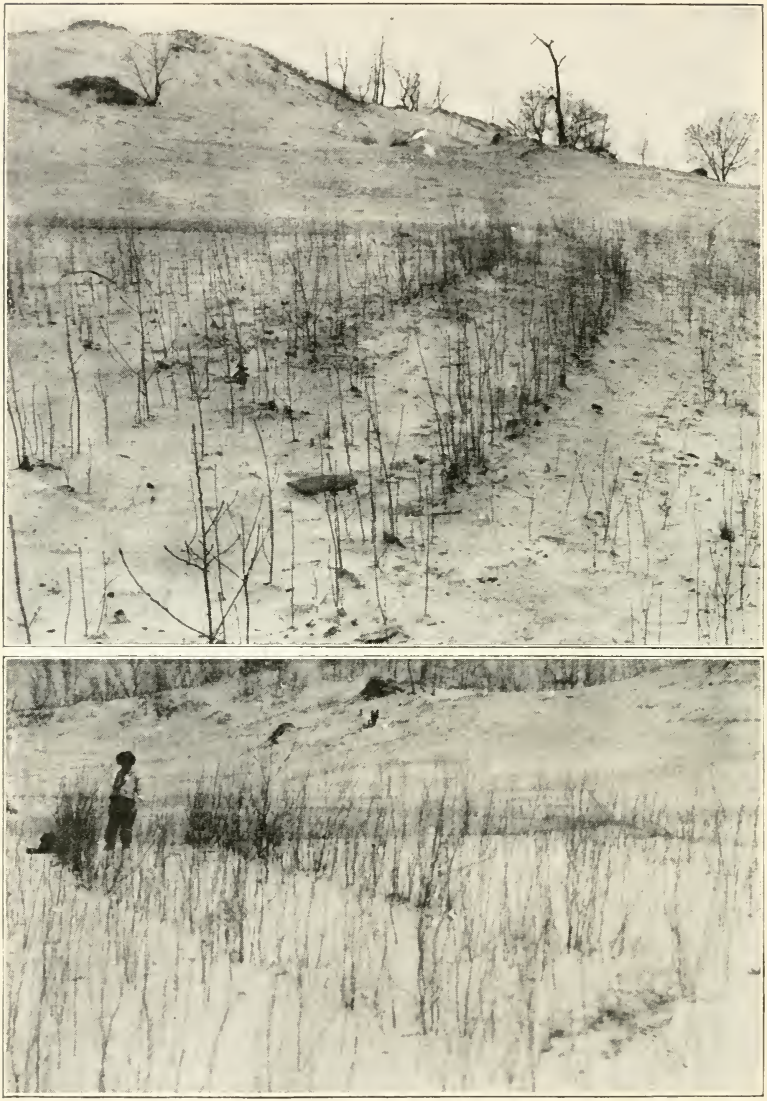
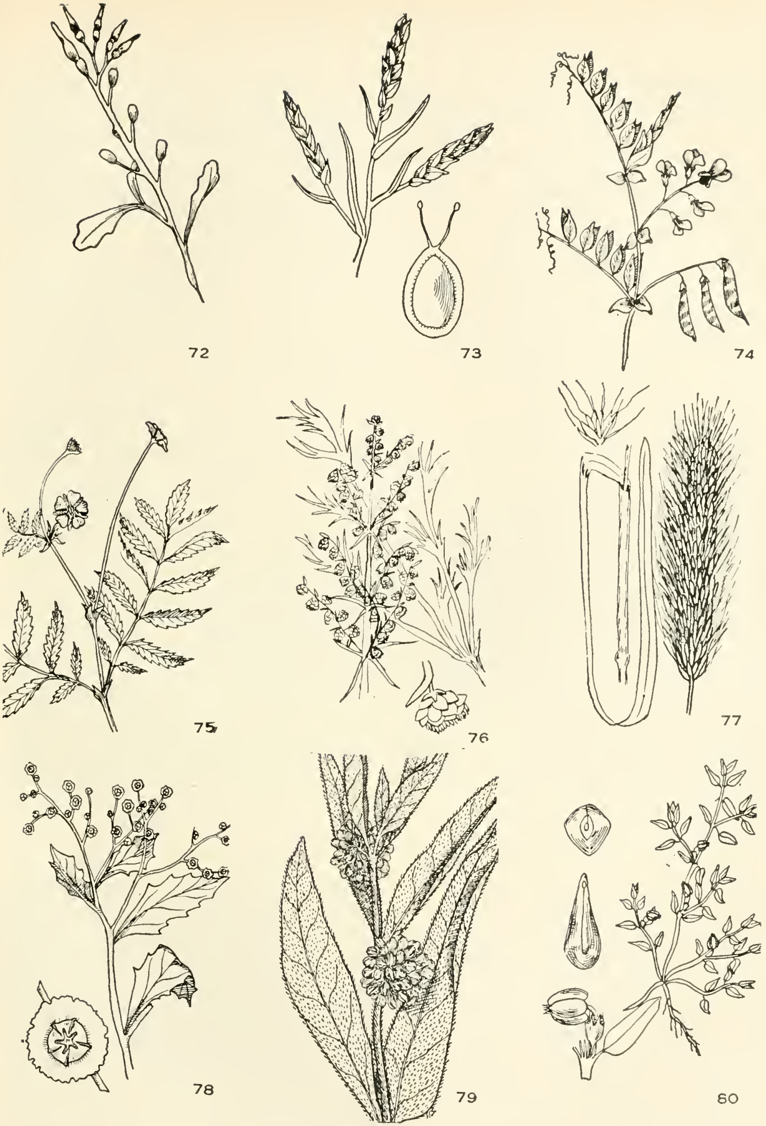


FIG. 71.—Upper: A double row of cottonwood seedlings near Mineral Springs, Indiana. Lower: The same two years later. Note the forming dune is nearly knee-high.



Figs. 72–80: Fig. 72.—Sea rocket, *Cakile edentula;* Fig. 73.—Bugseed, *Corispermum hyssopifolium;* Fig. 74—Beach pea, *Lathyrus maritimus;* Fig. 75.—Cinquefoil, *Potentilla Anserina;* Fig. 76.—Wormwood, *Artemisia caudata;* Fig. 77.—Rye grass, *Elymus canadensis;* Fig. 78.—Winged pigweed, *Cycloloma atriplicifolium;* Fig. 79.—Green milkweed, *Acerates viridiflora;* Fig. 80.—Seaside spurge, *Euphorbia polygonifolia.*

and bugseed are the most common plants. Back somewhat farther the pioneers of vegetation begin to get a foothold in the permanent beach association; such are the beach pea, beach cinquefoil, wormwood, cocklebur, and sand thistle.

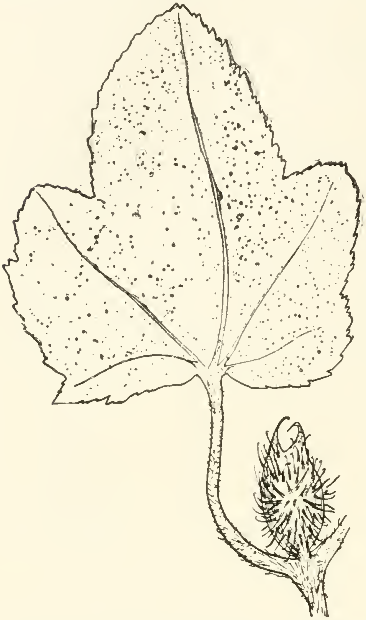


FIG. 81.—Leaf and one fruit of cocklebur, *Xanthium echinatum*.

The sea rocket (Fig. 72) is a plant with succulent stems and thick fleshy leaves. The flowers are light purple, appearing like those of the garden radish. The pods are two-jointed. The bugseed (Fig. 73) is an annual with slender awl-shaped leaves. The fruits are numerous, small, hard, and have a winged margin. The beach pea (Fig. 74) is a stout trailing plant with leafy expansions or stipules at the base of the compound leaves. The flowers are large, an inch or more long, purple. The beach cinquefoil, *Potentilla canadensis*, is a plant with palmately compound leaves, having three to five leaflets. It multiplies by runners somewhat as a strawberry plant does. The blossoms are somewhat like those of the strawberry, though small and pale yellow to white. Another species, *Potentilla Anserina* (Fig. 75), is found in the same locality. Wormwood (Fig. 76) is a plant with a finely dissected, densely hairy leaf. It is very bitter to the taste. Cocklebur (Fig. 81) is so common

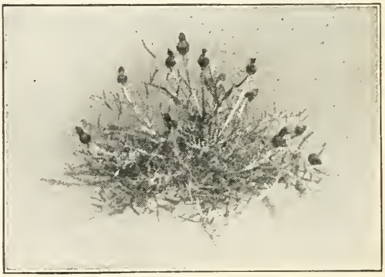


FIG. 82.—Sand thistle, *Cirsium Pitcheri*

a weed everywhere that its burrs and coarse leaves are familiar. The sand thistle (Fig. 82) is a pale, hairy thistle with very weak prickers and heads of cream-colored blossoms.

Then comes the fore-dune association (Fig. 83) including, in addition to the foregoing, the sand reed grass, marram grass, rye grass (*Elymus*) winged pigweed, green milkweed, seaside spurge, mullein, sand cherry, and the furry willow. The sand reed grass (Fig. 84) grows in clumps from underground running root stalks. It bears its seeds in a spreading cluster. Where its leaves sheath the stalk they bear a ring of short hairs. Marram grass (Fig. 85) also grows in clumps, springing from underground running root stalks, and bears its seeds on a dense spike. Its leaves are tipped with a long slender point. There is no ring of hairs on the leaves where they clasp the stem. Rye grass (Fig. 77) or wild rye looks like growing grain. The leaves are broad. The seedlike fruits grow in a spike, each one bearing a long bristle or awl. The winged pigweed (Fig. 78) is a much-branched, coarse annual. Very small scattered flowers give it a characteristic appearance shown in the illustration. Green milkweed (Fig. 79) has milky juice and broad, glossy, almost sessile leaves. Its flowers are green, and their hoods have no crests

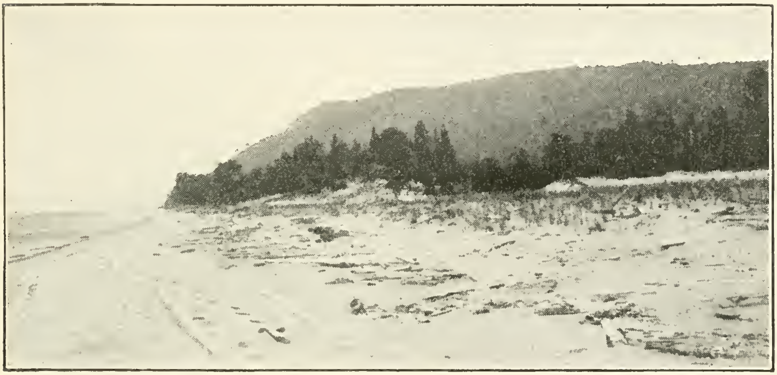


FIG. 83.—The beach, the storm beach, fore-dune, pine and oak associations. The cottonwood zone is missing here.

such as are present in common field milkweed. Seaside spurge (Fig. 80) has milky juice. The leaves are long and narrow, with squarish ends. It is a much-branched plant, low and spreading. Mullein is the common weed known by its thick leaves, densely covered with hair which gives them a velvety feel. It is also known as velvet plant. Sand cherry (Fig. 86) has a smooth, reddish bark characteristic of cherry trees. This bark peels off in thin sheets and is marked by horizontal lenticels. The leaves are long, narrow, larger at the outer end than at the stem, and the fruit is a good-sized cherry, one-half inch or more in diameter, that is quite tasty though somewhat acrid. The furry willow (Fig. 87), *Salix syrticola*, is a low shrub with twigs and leaves covered with dense hair. The leaves have large stipules. The broad-leaved willow, *Salix glaucophylla*, is also found on the fore-dune zone. It is also a shrub with leaves that are dark green, shiny above, and light green below.

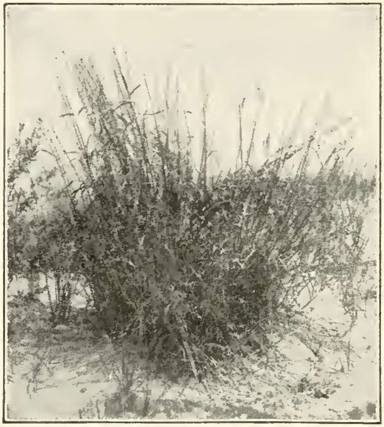


Fig. 84.—Long-leaved sand reed, *Calamovilfa longifolia.*

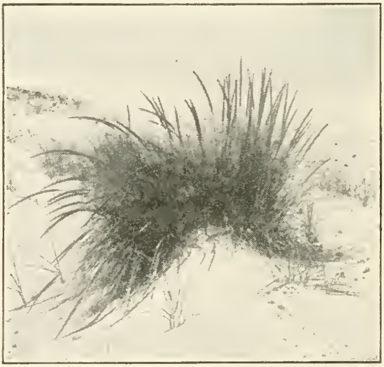


Fig. 85.—Marram grass, *Ammophila arenaria.*

Next comes the cottonwood zone (Fig. 88). The cottonwood tree is the one tree that can stand the open dunes. It is one of the poplars (*Populus deltoides*), recognized by its broadly triangular leaves that are borne on flattened stalks. The buds are long, tapering, and curve outward. The twigs especially on young trees have sharp ridges running down the bark below the buds. It thrives as the sand buries it. While other trees sicken and die, the cottonwood literally rises to the emergency, and grows so as to keep its head above the accumulating sand. Moreover, it sends out roots all the way up and down its buried trunk to help secure needed moisture for its vigorous growth. What appear like low cottonwoods on top of a dune are really the topmost branches of a tree whose original roots may be buried a hundred feet below the rising crest of the dune. Cottonwood roots run out many yards through the sand in search of moisture.

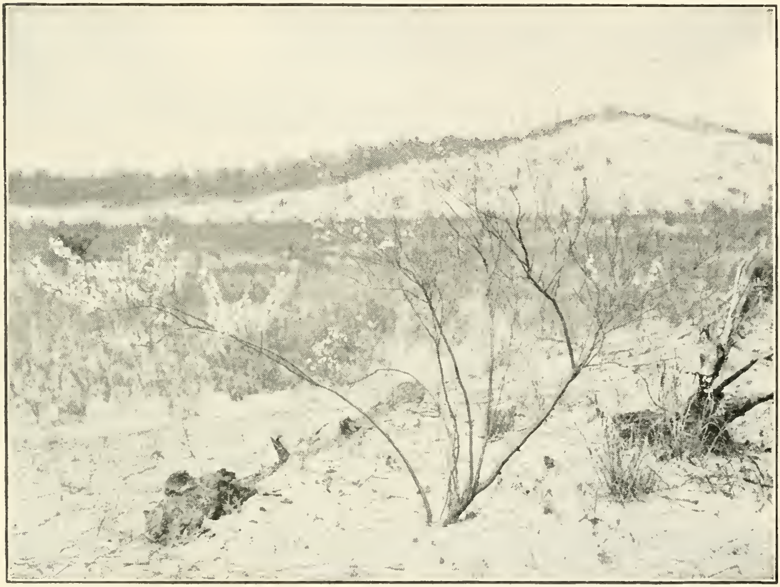


Fig. 86.—Sand cherry, *Prunus pumila*, in the fore-dune association

Miniature dunes may be built up around clumps of bunch grass, sand cherry, or prostrate juniper (Fig. 69), but the mainstay of the big dune is the bunch of cottonwoods whose seedlings caused it to start, and that have grown as rapidly as the dune

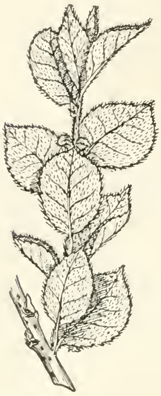


FIG. 87.—The furry willow, *Salix syrticola.*

has increased in height. There are many other plants that assist the cottonwoods to stay the onward-moving sands. Bunch grasses and the others mentioned above are efficient binders. Their intertangled roots serve to enmesh the sand and prevent its being blown away. Sand cherry, the smooth and glandular willows, bittersweet, horsetail, are all forms that can stand the open sand areas along with the cottonwood and when once established help to hold the shifting sand. So these form a part of the *cottonwood association.* To say that these plants thrive here does not mean that they live only in such barren places. The cottonwood grows magnificently on rich soil; but here on the sands it is without competitors. The red-osier dogwood is found growing luxuriantly on the margins of the swamps, but it can endure the dunes and keep its head above even rapidly accumulating sand (Fig. 89).

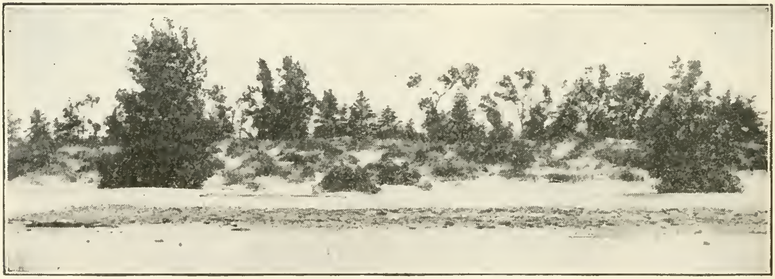


FIG. 88.—The cottonwood zone with fore-dune and storm beach in foreground

The efforts of the plants to establish themselves and transform the shifting sands into permanent soil would be in vain were it not for the fact that the lake is constantly piling up new dunes in front of those already formed. These, as they grow, cut off the brunt of the wind from those in the rear so that the conditions of life are less severe on these protected dunes, and vegetation may grow more luxuriantly. By the time that several generations of cottonwoods, together with many more

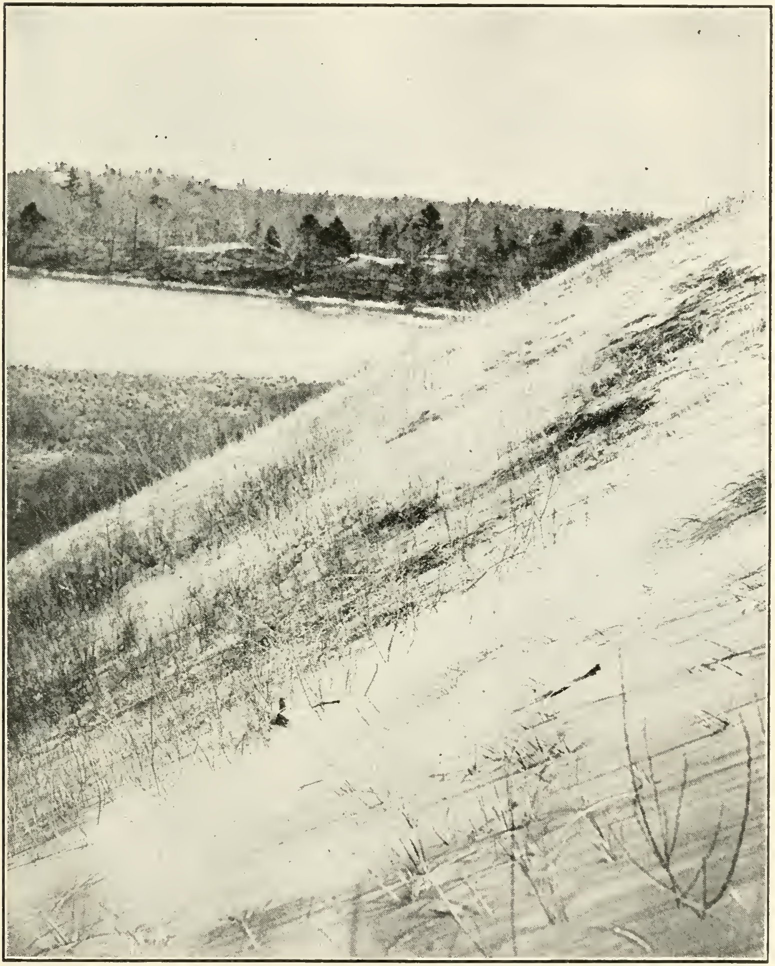


FIG. 89.—Steep side of a dune with red-osier dogwood, *Cornus stolonifera*, and bunch grass serving as binders.

of the shorter-lived shrubs and the associated annuals, have lived and died, the sand has become so altered by their decomposed remains as to be capable of holding enough moisture to support a new set of plants.

Jack pines, then white pines, and a whole new set of associated plants, begin to change the appearance of the dunes, back in the *pine association* (Fig. 90). The arbor vitae, improperly called the white cedar, the red cedar, the common juniper, and the prostrate juniper, are conspicuous and give a northern air to these dune areas. The associated plants are mostly those usually recognized as northerners. The bearberry covers the ground with its glistening leaves; shinleaf, checkerberry, prince's pine, star flower, and false lily-of-the-valley are common. Bluebells, puccoon, horsemint, hairy phlox, St. John's-wort, star grass, Solomon's seal—both true and false—bellwort, and the wild rose make these dunes gay with blossoms. Staghorn sumac, dwarf sumac, aromatic sumac, and red-osier dogwood make dense thickets of shrubs, while bittersweet, woodbine, poison ivy, and grape add to their impenetrability.

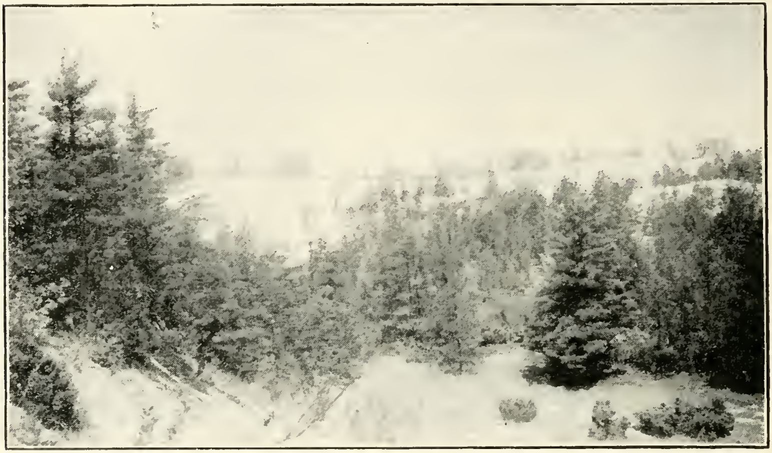


Fig. 90.—At the edge of the pine association looking toward the cottonwood zone. The tall trees at left are white pines, *Pinus strobus*. At the right are red cedars, *Juniperus virginiana*, with little bunches of spreading juniper, *Juniperus communis*.

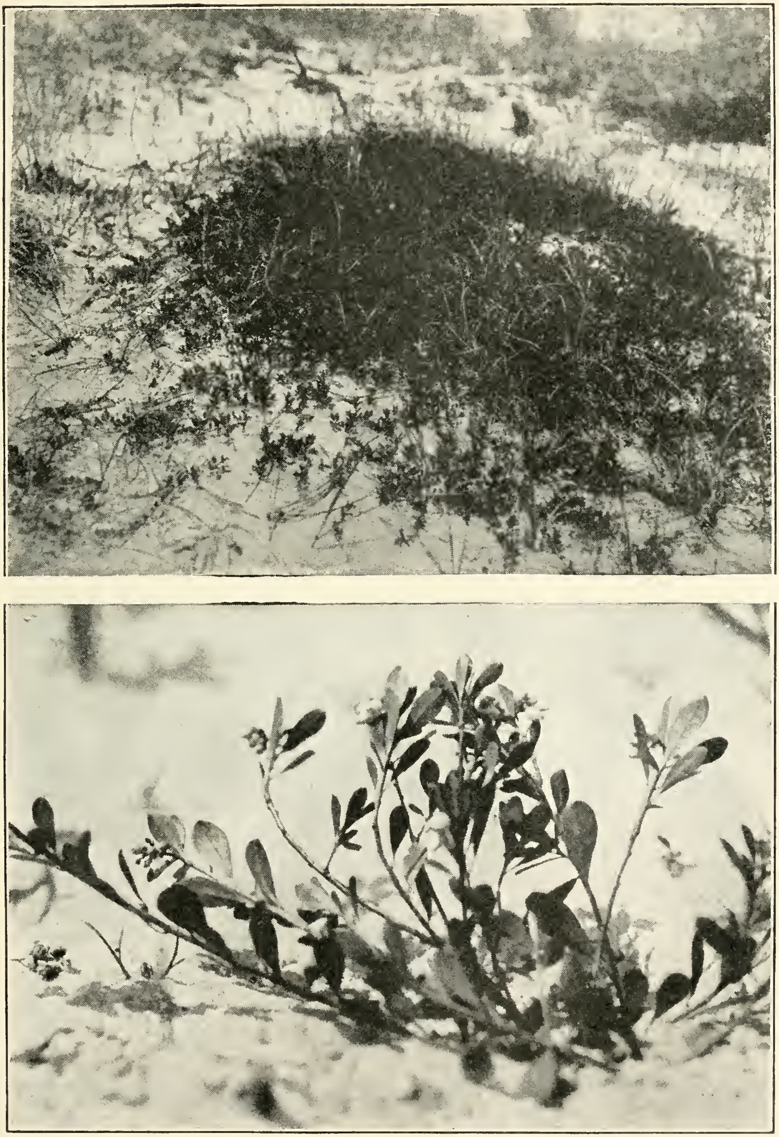
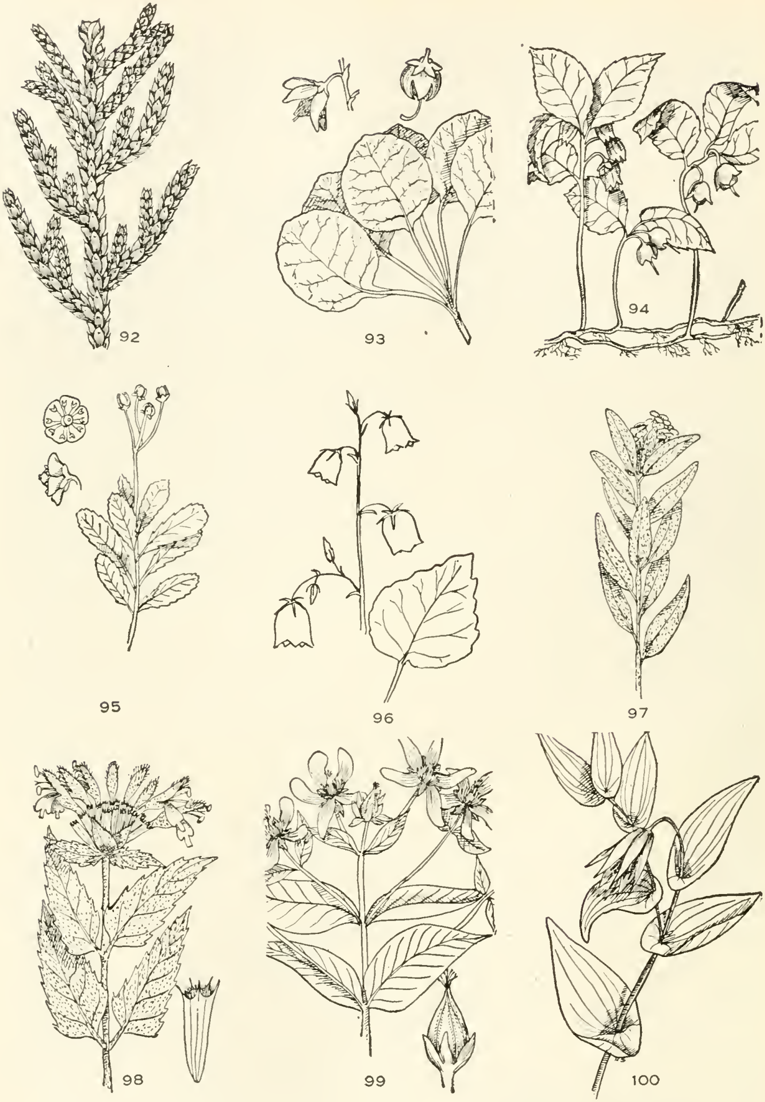


Fig. 91.—The bearberry, *Arctostaphylos Uva-ursi:* above habitat, below detail



Figs. 92–100: Fig. 92.—Spray of arbor vitae, *Thuja occidentalis;* Fig. 93.—Shinleaf, *Pyrola elliptica;* Fig. 94.—Checkerberry, *Gaultheria procumbens;* Fig. 95.—Prince's pine, *Chimaphila umbellata;* Fig. 96.—Bluebell, *Campanula rotundifolia;* Fig. 97.—Puccoon, *Lithospermum canescens;* Fig. 98.—Horsemint, *Monarda punctata;* Fig. 99.—St. John's-wort, *Hypericum Kalmianum;* Fig. 100.—Bellwort, *Uvularia grandiflora.*

The pines among the evergreens bear their needles in clusters, the jack pine having two short needles in each group, the white pine five long ones. The arbor vitae (Fig. 92) has scalelike, diminutive leaves that overlap. The twig is flat and fanlike. The red cedar is a juniper. All the junipers have very sharp needles, rather irregularly borne on the twig. The red cedar (Fig. 90) is tall, plumelike, growing to be a good-sized tree, though usually not large in the dunes. The needles are quite small, crowded in pairs, each one opposite its mate. The common juniper (Fig. 90) is a spreading shrub, while the prostrate juniper (Fig. 69) lies close to the ground, a straggling shrub. The former has the leaves in threes, whorled on the stem, the latter has them in pairs opposite each other. The bearberry or kinnikinnick (Fig. 91) is a sprawling shrub that grows often in great masses. The oblong leaves are leathery and lustrous green the year round. The flowers are little pink, pendant urns, the fruit a red berry with seeds that occupy most

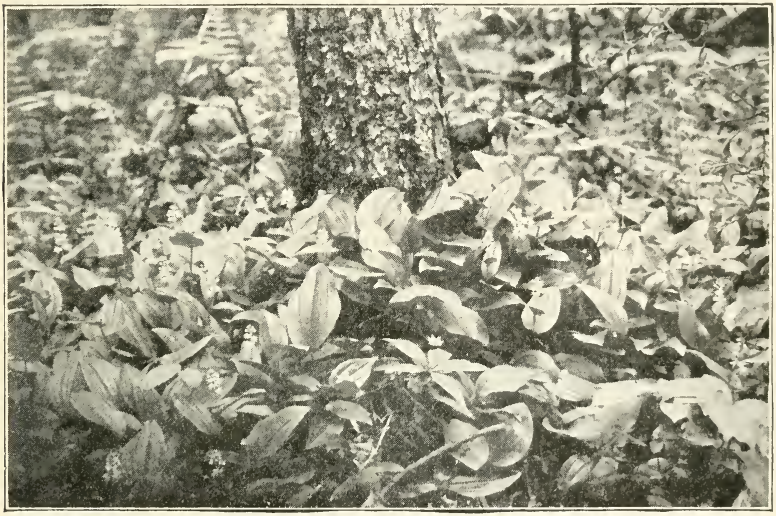


FIG. 101.—Star flower, *Trientalis americana* (center foreground) and false lily-of-the-valley, *Maianthemum canadense*, in pine zone at the Dunes.

of it. Shinleaf (Fig. 93), checkerberry (Fig. 94), and prince's pine (Fig. 95) are all small, low, shrubby plants with evergreen leaves, belonging to the heath family. Shinleaf has rounded leaves, and its flowers are borne in a loose cluster somewhat like those of the lily-of-the-valley. The checkerberry has three or four glistening, thick, leathery leaves. It stands only two or three inches high. The flavor of the leaves is that of wintergreen candy. The leaves of prince's pine are long, narrow, toothed on the edges, and crowded on the short upright stalks. Star flower (Fig. 101) is a low plant bearing a single, delicate, white blossom above a whorl of lance-shaped leaves. False lily-of-the-valley (*Maianthemum canadense*) has a raceme of small white flowers borne on a plant with two or three parallel-veined, thin leaves. Bluebell (Fig. 96) has linear leaves and delicate blue, fairly

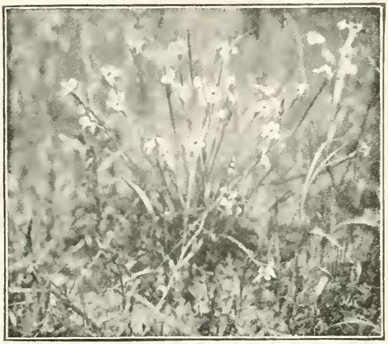


Fig. 102.—Blue star grass, *Sisyrinchium angustifolium.*

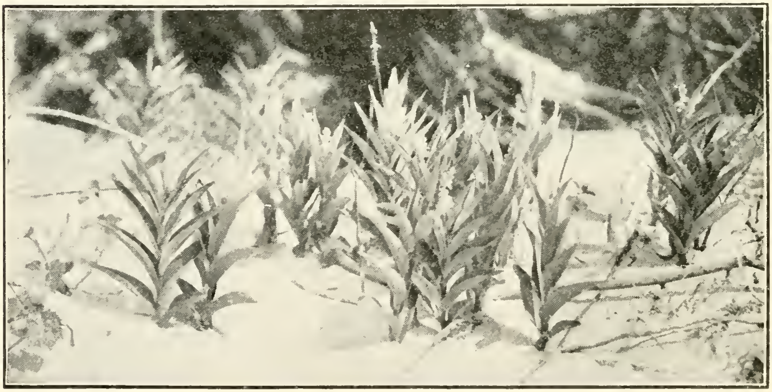
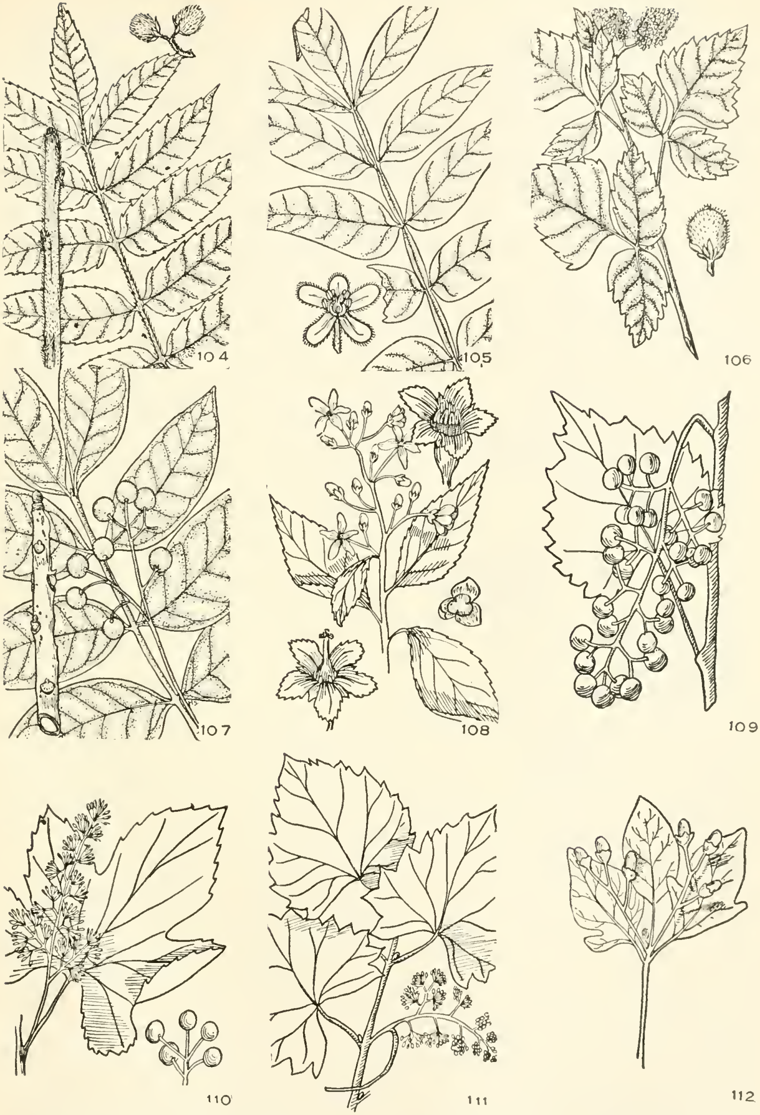


Fig. 103.—False Solomon's seal, *Smilacina racemosa*

large, bell-shaped blossoms. Puccoon (Fig. 97) is a low hairy plant with clusters of brilliant orange blossoms. Horsemint (Fig. 98) is an annual plant with strongly serrated leaves. The yellow flowers are not large but are subtended by conspicuous yellowish-purple bracts that make the blossom clusters at the ends of the stalks showy affairs. The phlox in the dunes is so like the garden flower of the same name it will be promptly recognized. There are three species here. The hairy phlox has a hairy stem and sharp, pointed, lance-shaped or linear leaves. This is the only one common in the pine association, though it is also found still farther back. The St. John's-wort (Fig. 99) has leaves that are dotted with fine translucent spots. The flowers are yellow and of quite good size. Star grass is not a grass really, though its leaves are long and narrow like those of grass. The star-shaped flowers, together with the narrow grasslike leaves, make it easily recognized. Two species are common: one bears yellow flowers—the yellow star grass—the other, blue flowers—blue-eyed grass (Fig. 102). Solomon's seal receives its name from the fact that it has a long underground stem on which are a number of circular scars like seals, each being impressed at the point where a year's growth above the ground was attached. The leaves of the plant are broadly lance-shaped and parallel-veined. The flowers are borne in pairs on the axils of the upper leaves of the pliant, unbranched stem. False Solomon's seal or spikenard (Fig. 103) is quite similar but a somewhat lustier plant, and the blossoms are in a cluster at the end of the stem instead of in the axils of the leaves. *Rosa blanda* is the common wild rose of the dunes, though *R. humilis* and *R. acicularis* are also found frequently, and *R. carolina* is to be encountered along the borders of the swales. *R. blanda* is low, has its smaller branches free from prickles, and its flowers are usually clustered. Its leaflets are rounded at the outer end, wedge shaped next the stem. *R. acicularis* is well armed; its flowers are solitary as a rule. Its leaflets are obtuse at the apex, rounded at the base. *R. humilis* is slender stemmed, armed with slender prickles. Its leaflets are acute at both ends. The bellwort (Fig. 100) is very abundant in spots in spring. It also has parallel-veined leaves, lance shaped, borne on a pliant, unbranched, low stem. The flower is single, one on each plant, a pendant, yellow, lily-like blossom.

Staghorn sumac (Fig. 104) is a shrub readily recognized by its coarse, pithy twigs covered with velvety hairs. The dwarf sumac (Fig. 105) is a small edition of the staghorn with this marked difference, that in the latter the leafstalks are margined with a wing between the leaflets of the pinnately compound leaves. The aromatic sumac (Fig. 106) is a struggling, low shrub with softly hairy, young leaves. The leaves have three leaflets and have a pleasant odor when crushed. In the same genus (*Rhus*) of innocent plants comes the poison ivy and its even more poisonous brother, poison sumac (Fig. 107), also called poison dogwood or poison elder. It grows in the swamps, not on the dunes. But the poison ivy (Fig. 113) is very common in the dunes, particularly in the pine association. It is a vine, though often appearing as a shrub. The leaf has three leaflets, as has that of the poison sumac, and like the latter the fruit is white, clustered, appearing berry-like. Woodbine, also a vine, drapes itself on trees and shrubs or creeps along the ground. Its leaves have five leaflets growing from a common center. Bittersweet (Fig. 108) is also a climbing vine with glistening, green, lance-shaped leaves and a red fruit in autumn, looking like a berry in the center of four yellowish bracts that roll back to disclose it. Three species of grapes—*Vitis cordifolia* (Fig. 109), the frost grape, *V. aestivalis* (Fig. 110), the summer grape, and *V. vulpinus* (Fig. 111), the river-bank grape—are found in the dunes—the former on the cottonwood dunes, the latter in the pine and still later associations. *V. vulpinus* is most likely to be found on the margins of swales and swamps. The frost grape has small, shiny, black berries; the summer grape, black berries with a bloom; the river-bank grape, blue berries with a bloom.



FIGS. 104–112: Fig. 104.—Staghorn sumac, *Rhus typhina;* Fig. 105.—Dwarf sumac, *R. copallina;* Fig. 106.—Aromatic sumac, *R. canadensis;* Fig. 107.—Poison sumac, *R. Vernix;* Fig. 108.—Bittersweet, *Celastrus scandens;* Fig. 109.—Frost grape, *Vitis cordifolia;* Fig. 110.—Summer grape, *V. aestivalis;* Fig. 111.—River-bank grape, *V. vulpinus;* Fig. 112.—Sassafras, *Sassafras variifolium.*

Back of the pine association comes in order the *black oak association.* No single association of the dune complex is more distinctive than this association, so many of the plants are peculiar to it. The black and chestnut oaks are the common large trees. There is a wealth of characteristic small trees and shrubs, sassafras, shadbush, pincherry, chokecherry, hop tree, dwarf blackberry, known by its stiff prickers, huckleberry, blueberry, bush honeysuckle. The conspicuous herbaceous flowering plants are equally characteristic; the spiderwort, bastard toadflax, anemone, columbine, rock cress, lupine, hoary pea, bush clover, wild geranium, milkweed, flowering spurge, bird's-foot, and arrow-leaved violets, prickly-pear cactus (Fig. 60), butterfly weed, green milkweed, wild bergamot, lousewort, blazing star (Fig. 134), the goldenrods, the sunflowers, and yellow daisy.

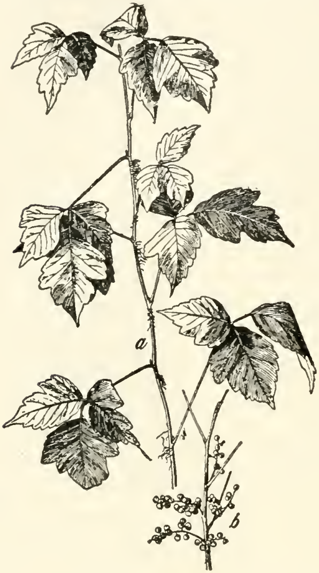
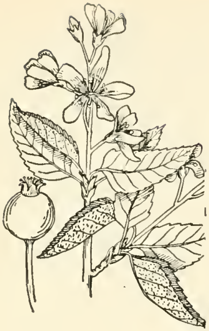


Fig. 113.—Poison ivy, *Rhus Toxicodendron; a,* spray showing aerial rootlets and leaves; *b,* fruit —both one-fourth natural size (*Farmers' Bulletin No. 86*).

Sassafras (Fig. 112) is readily known by its green twigs with the sassafras taste and its mitten-shaped leaves. Shadbush (Fig. 114), also known as sugar plum, service bush, and June berry, is a small tree with smooth, light-gray bark. The leaves of the species in the dunes are thin, and the edges finely saw-toothed. The tree bears clusters of rather large white blossoms in the spring and later edible fruits that turn red and then purple as they ripen. Pin and chokecherries are known by their reddish bark that peels off in thin layers like birch bark, though not so readily, and that is marked by conspicuous horizontal lenticels. Both trees have the blossoms in clusters. In the



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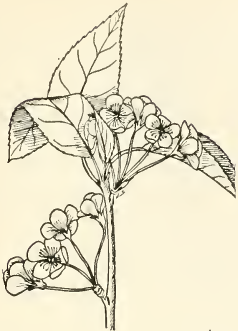

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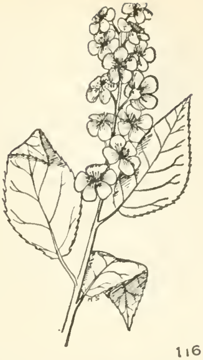

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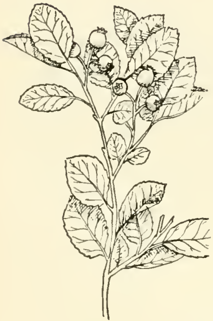

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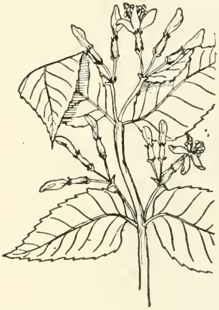

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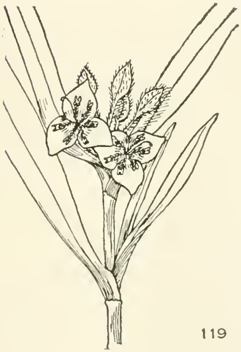

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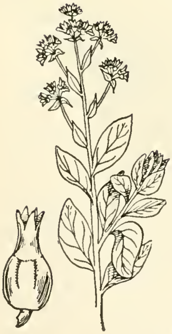

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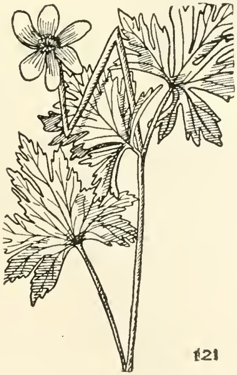

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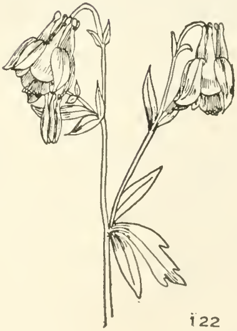

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Figs. 114–122: Fig. 114.—Shadbush, *Amelanchier canadensis;* Fig. 115.—Pin cherry, *Prunus pennsylvanica;* Fig. 116.—Chokecherry, *P. virginiana;* Fig. 117.—Huckleberry, *Gaylussacia baccata;* Fig. 118.—Bush honeysuckle, *Diervilla Lonicera;* Fig. 119.—Spiderwort, *Tradescantia virginica;* Fig. 120.—Bastard toadflax, *Comandra umbellata;* Fig. 121.—Anemone, thimble weed, *Anemone cylindrica;* Fig. 122.—Columbine, *Aquilegia canadensis.*

former (Fig. 115) the individual flower stalks radiate from a common point; in the latter (Fig. 116) they come off singly from a common, main stalk. The fruits are, of course, similarly clustered. The hop tree, really a shrub, is known by its leaf made of three leaflets and its clustered fruits, achenes with wide, dry, thin borders, looking somewhat like dried hops. The blueberries and huckleberries (Fig. 117) are low shrubs with rather thick, leathery leaves, pink bell-shaped flowers and bluish berries for fruits. In the autumn their leaves turn shades of dull red and give a brilliant cast to great stretches of the dunes where they are abundant, like the autumn colors of the Scotch heathers. These plants belong to the heath family. Bush honeysuckle (Fig. 118) is a low, opposite-leaved shrub with yellow flowers in clusters of three. The corolla is funnelform, the flowers conspicuous. As they age they turn darker or even scarlet to crimson.

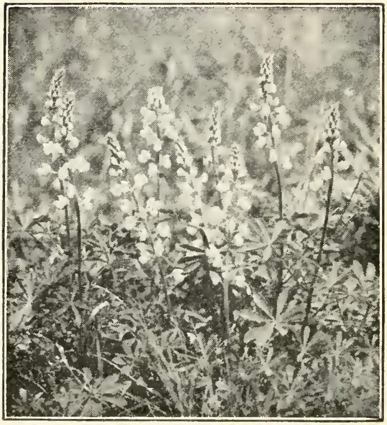
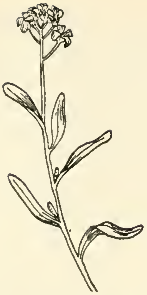


Fig. 123.—Lupine, *Lupinus perennis*

Spiderwort (Fig. 119) is known by its grasslike leaves that exude a mucilaginous sap when broken. Bastard toadflax (Fig. 120) is a low plant with a cluster of small white flowers. *Anemone cylindrica* (Fig. 121) and columbine (Fig. 122) are familiar and may be recognized from the illustrations. Rock cress (Fig. 124) is one of the mustard family with small white clustered flowers, each with four petals. The lupine (Fig. 123) has palmately compound leaves and large spikes of blue, pealike flowers.

The hoary pea (Fig. 125) or wild sweet pea is an erect, unbranched plant, a foot or two high, with typical, clustered, pea-shaped blossoms that are yellowish purple. The leaves are



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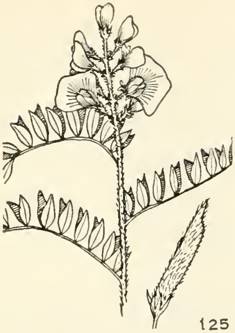

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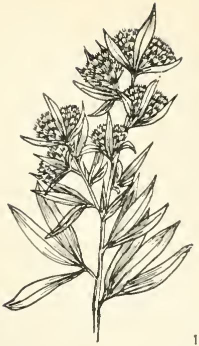

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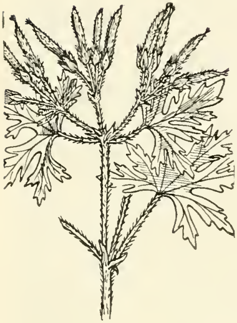

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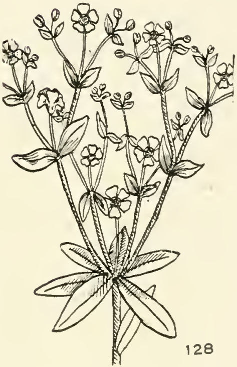

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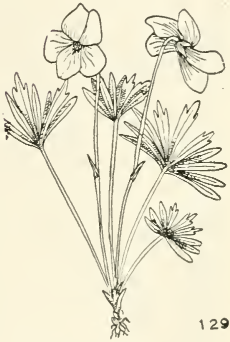

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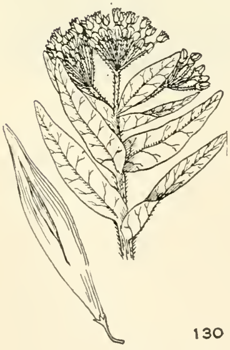

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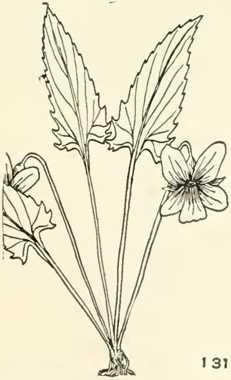

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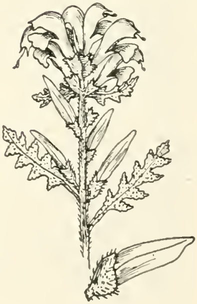

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FIGS. 124–132: Fig. 124.—Rock cress, *Arabis lyrata;* Fig. 125.—Hoary pea, *Tephrosia virginiana;* Fig. 126.—Bush clover, *Lespedeza capitata;* Fig. 127.—Wild geranium, *Geranium carolinianum;* Fig. 128.—Flowering spurge, *Euphorbia corollata;* Fig. 129.—Bird's-foot violet, *Viola pedata;* Fig. 130.—Butterfly weed, *Asclepias tuberosa;* Fig. 131.—Arrow-leaved violet, *Viola sagittata;* Fig. 132.—Lousewort, *Pedicularis canadensis.*

compound with seven to twenty-five leaflets. The roots are fibrous and very tough, serving well for string on emergency. Bush clover (Fig. 126) is a tall slender plant with a covering of silky hairs. The compound leaves consist of three leaflets which are long and narrow. The round heads of yellowish blossoms are sessile in the axils of the upper leaves. The wild geranium of the black oak association is *Geranium carolinianum* (Fig. 127). The leaf is shaped much like that of the sweet-scented, deeply cut leaf of the common garden geranium. The flower is about one-half inch broad, pale purple, and the seed pod bears a short beak. *Geranium maculatum*, a closely related species, is found farther back in the mixed oak association. Flowering spurge (Fig. 128) has an erect stem with narrow leaves. At its top a cluster of stalks arises from a common point surrounded by a whorl of green bracts. These stalks branch rapidly, and each branch terminates in a white blossom. The juice of the plant is milky. Bird's-foot and arrow-leaved violets may be identified from the figures of the plants (Figs. 129, 131). Butterfly weed

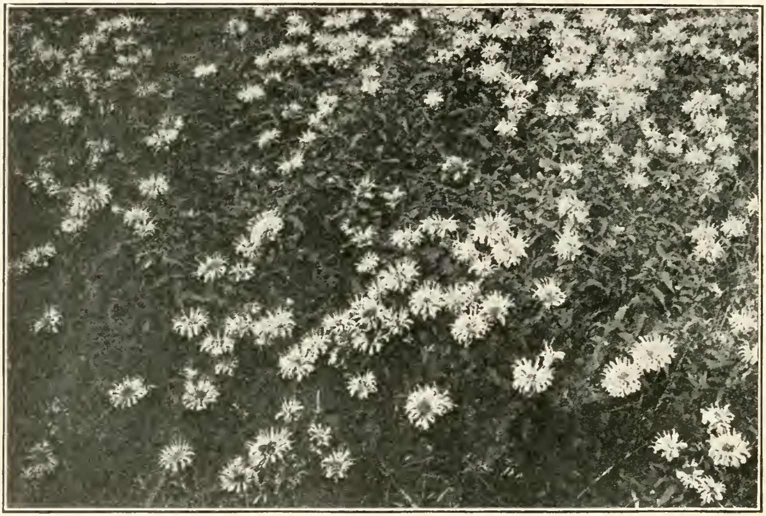


Fig. 133.—Wild bergamot, *Monarda fistulosa*

is one of the milkweeds, although it does not have a milky juice. The clustered blossoms are brilliant orange and shaped like those of the common field milkweed (Fig. 130). Wild bergamot (Fig. 133) has a characteristic odor. The corolla is long, violet or pink, and hairy in the throat. The blossoms are clustered and the cluster is subtended by bracts, the upper ones of which are colored white or purplish. Lousewort (Fig. 132) is a low hairy plant with pinnately parted leaves and yellow flowers crowded by a spike at the top of the stem. The blazing stars (Fig. 134) are tall, slender, unbranched composite plants with small narrow leaves. They are so slender they look like fuzzy green stakes set in the ground. The two common species in the black oak area are *Liatris cylindrica* and *L. scariosa*. The former has only a few heads and reddish-purple flowers, the latter many heads on the stalk and these good sized.

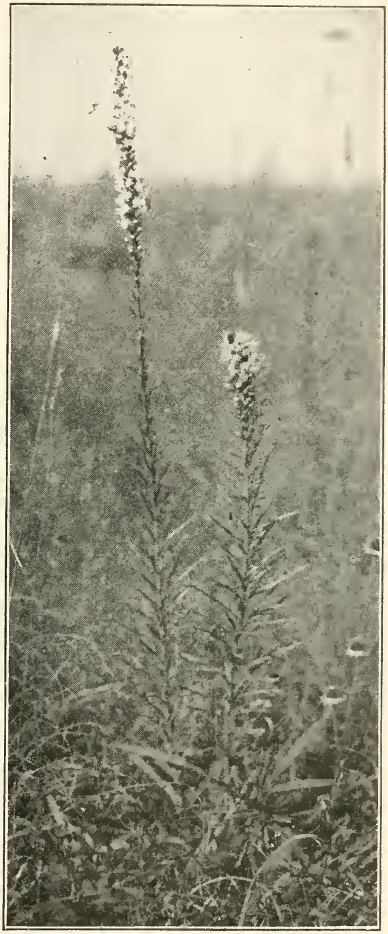


FIG. 134.—Blazing star, *Liatris spicata*

The mixed oak association (Fig. 135) is characterized by black, chestnut, white, and red oaks (Fig. 136), with a mixture of slippery or red elms and basswoods, while among the smaller trees water beech and hop hornbeam are peculiar. Yellow lady's-slipper, hepatica, May apple, *Geranium maculatum*, Canada violet, the long-spurred violet, and rattlesnake root are characteristic and indicate the approach of the climax forest association which will be discussed in a later chapter.

The elms are known by their vase shape and by the fact that the buds come out on opposite sides of the twigs so that the branch with its twigs is always flat, spread out fanwise. The last feature is also common to the basswood, and these are the only trees in our area that do possess this character. The basswood has large heart-shaped leaves, lopsided at the base. The bark of the tree is smooth, except that it is often riddled with the holes of the sapsucker arranged in rows around the trunk. Water beech (Fig. 137) has a fluted trunk with smooth bark. Hop hornbeam has a finely shredded bark that pulls off in long stringy strips. Both these trees have leaves that resemble those of the elm.

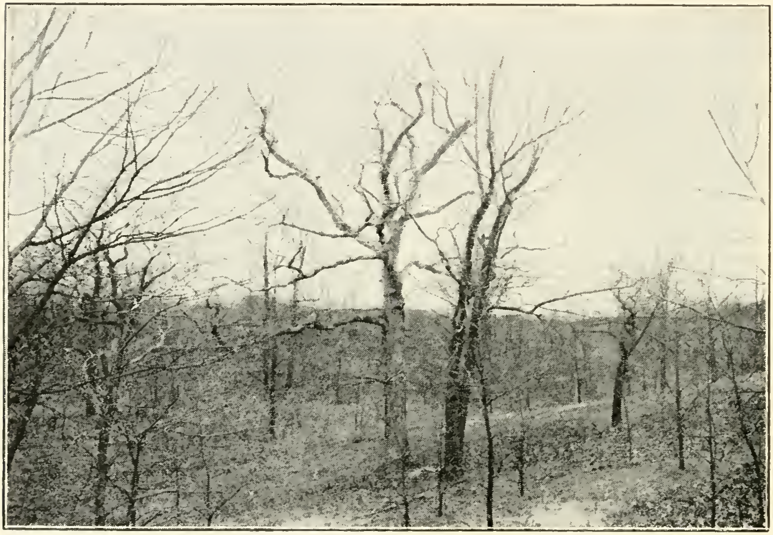


FIG. 135.—Mixed oak-dune area. Note large white oak, *Quercus alba*, in center of picture; near it are red oaks, *Q. rubra*.

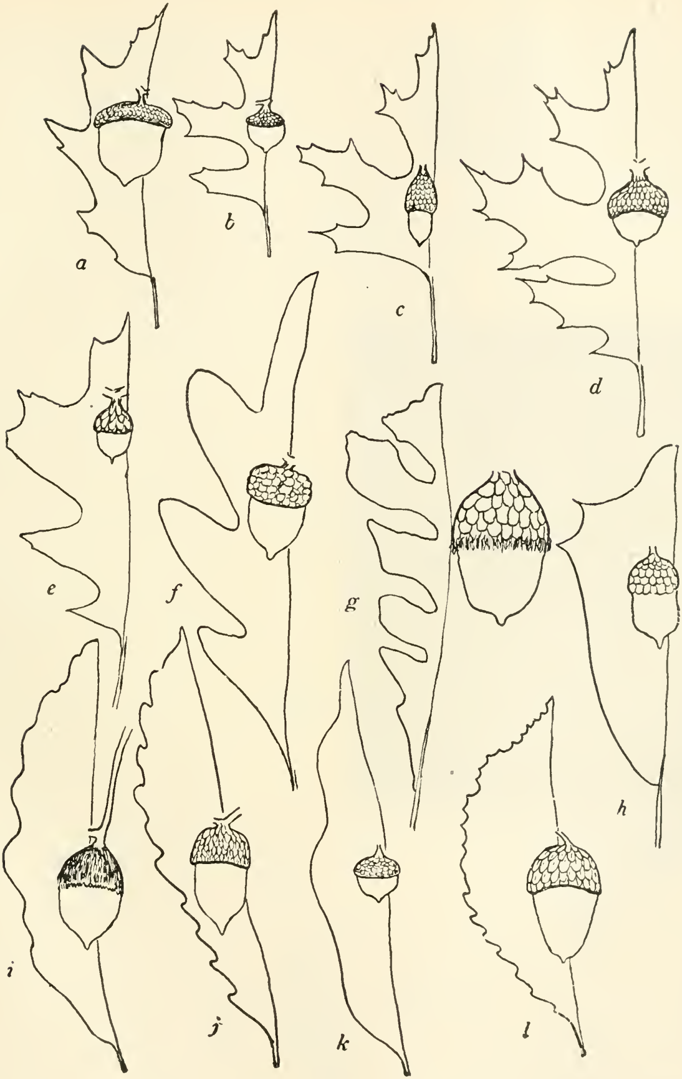


FIG. 136.—Leaves and acorns of the oaks: *a*, red oak (*Quercus rubra*); *b*, pin or swamp oak (*Q. palustris*); *c*, northern pin oak (*Q. ellipsoidalis*); *d*, scarlet oak (*Q. coccinea*); *e*, black oak (*Q. velutina*); *f*, white oak (*Q. alba*); *g*, bur oak (*Q. macrocarpa*); *h*, blackjack (*Q. marylandica*); *i*, swamp white oak (*Q. bicolor*); *j*, cinquapin oak (*Q. Mühlenbergii*); *k*, shingle oak (*Q. imbricaria*); *l*, basket oak (*Q. Michauxii*).

The yellow lady's-slipper or moccasin flower can be recognized from the illustration, for it is so unusual a blossom (Fig. 138). Hepatica or liverwort (Fig. 139) has a three-lobed, dark, mottled leaf; the pale pink or lavender blossoms come early in the spring. May apple (Fig. 140) has large circular leaves, the stem attached at the center. The large creamy white blossoms spring from the fork of the stem, the blossoming plant always bearing two leaves. *Geranium maculatum* (Fig. 141) is similar to *G. carolinianum* of the black oak association. Its leaf is not as finely cut, having only five wedge-shaped lobes. The blossom is larger, nearly an inch across, and is light purple. Canada violet (Fig. 142) has a branched, leafy stem. The blossom is yellow tinged with violet on the outside, white inside. The long-spurred violet (Fig. 143) has so conspicuously long a spur that it is not to be mistaken for any other in the Chicago region. Both these violets are conspicuously present in the climax forest. Rattlesnake root, *Prenanthes alba*, is a composite with a stout and fairly high stem, bearing leaves roughly triangular, though very variable in form and lobing. The flowers are white, a dozen or so in a head with many heads in a cluster (Fig. 144). The summary of characteristic plants is given in the tabulation at the close of this chapter.

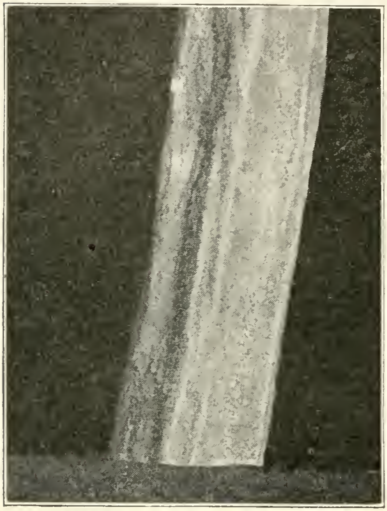


FIG. 137.—Trunk of water beech, *Carpinus caroliniana.*

The dune complex is by no means as simple as the foregoing discussion would seem to indicate, for there are additional physiographic changes that are constantly going on that interfere with the orderly progression sketched above. Whenever a new dune forms near the shore it diverts the strong winds in its neighborhood, for they are blocked in certain directions and go scurrying around its ends to blow with great vigor upon the older dunes from new angles. Not infrequently a poorly protected portion of some old dune is exposed thus to the scouring action of the sand-laden blast, and its relatively loose soil begins to blow away. What was an established dune may be more or less completely blown away (Fig. 14). Such blowouts are common, and they, of course, set back an area that had perhaps arrived at the black oak stage to the fore-dune stage of shifting sands in which only the few hardy annuals can grow.

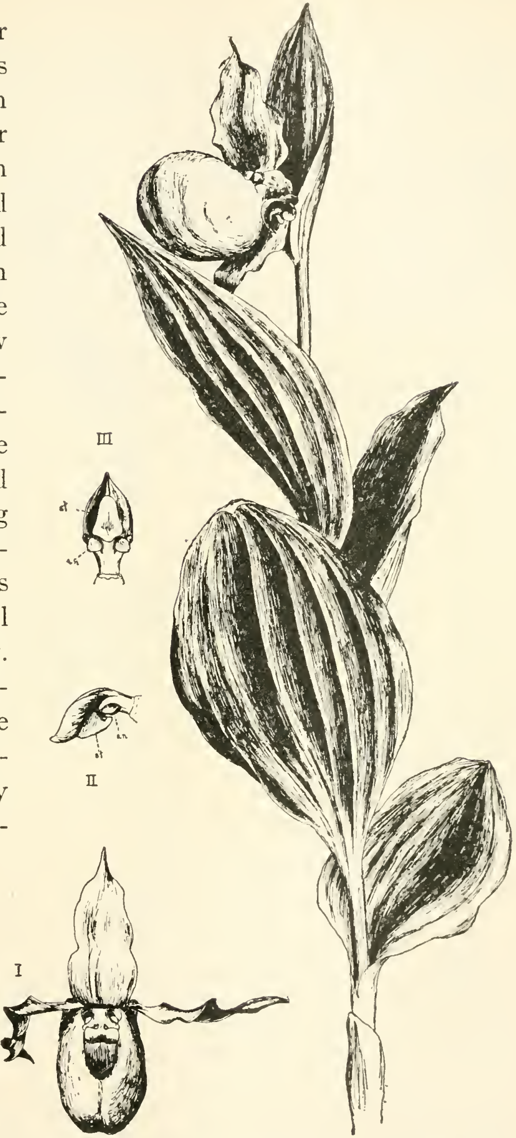
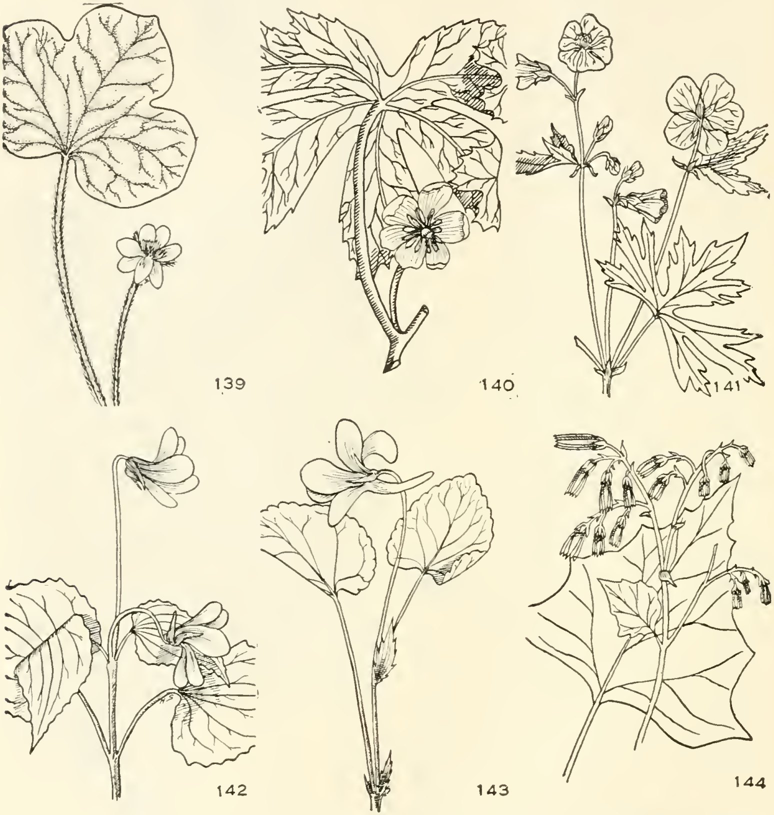


FIG. 138.—Yellow lady's-slipper, *Cypripedium parviflorum.* I. Front view of flower; II, III, side and front view of stigma and pollinia. Drawing by L. N. Johnson.

Moreover, such blow-outs uncover whatever the advancing dune buried. Under such conditions cottonwoods show their resiliency by sending out leafy shoots on old buried trunks that bear numerous roots. The buried pines, killed completely by their burial, stand out as giant skeletons, ghosts of their former selves. Such resurrections are no uncommon sight in these forest graveyards. Sometimes the fall of a great tree on one



Figs. 139–144: Fig. 139.—Hepatica, *Hepatica triloba;* Fig. 140.—May apple, *Podophyllum peltatum;* Fig. 141.—Wild geranium, *Geranium maculatum;* Fig. 142.—Canada violet, *Viola canadensis;* Fig. 143.—Long-spur violet, *V. rostrata;* Fig. 144.—Rattlesnake root, *Prenanthes alba.*

of the older dunes may expose enough of the loose sandy soil to the wind to initiate a blow-out.

It is very evident, then, that any given area in the dune region must be interpreted in the light of the complex of forces operative upon it. Frequently one will get into a region that is easily recognized as a cottonwood dune, a black oak association, or an interdunal swamp area, but not infrequently a particular spot will be in transitional conditions, a swamp being invaded by a moving dune perhaps, where within a rod one may pass from abundant water to bone-dry sand, from sphagnum and pitcher plants and a crowded vegetation to a barren sand slope. Old dunes are invaded by new ones, oaks superseded by cottonwoods. In fact, the zones as presented above, while often regularly placed, are at times mixed in a thorough jumble as blow-outs occur, moving dunes blow rapidly inland, or as the succession is here or there retarded or accelerated by other local conditions.

The following table presents a summary of the plant associations in the Dunes. It shows in which association each plant listed is most likely to occur. It would be well for the student to make a similar summary for each of the succeeding chapters viii–xiii.

Common Name of Plant	Scientific Name	Beach Assoc.	Fore-Dune Assoc.	Cottonwood Assoc.	Pine Assoc.	Black Oak Assoc.	Mixed Oak Assoc.
Trees, deciduous							
Balsam poplar	*Populus balsamifera*			*			
Basswood	*Tilia americana*						*
Chokecherry	*Prunus virginiana*					*	
Pincherry	*P. pennsylvanica*					*	
Cottonwood	*Populus deltoides*			*			
Elm, American white	*Ulmus americana*						*
Elm, red or slippery	*U. fulva*						*
Hop hornbeam	*Ostrya virginiana*						*
June berry	*Amelanchier canadensis*					*	
Oak, black	*Quercus velutina*					*	*
Oak, chestnut	*Q. Mühlenbergii*					*	*
Oak, red	*Q. rubra*						*
Oak, white	*Q. alba*						*
Sassafras	*Sassafras variifolium*					*	*
Shadbush (*see* June berry)							
Poplar (*see* Balsam poplar)							
Water beech	*Carpinus caroliniana*						*
Shrubs, deciduous							
Bearberry	*Arctostaphylos Uva-ursi*				*		
Blueberry	*Vaccinum pennsylvanicum*					*	
Blueberry, late	*V. vacillans*					*	
Cherry, sand	*Prunus pumila*		*	*			
Dogwood, flowering	*Cornus florida*						*
Dogwood, panicled	*C. paniculata*						*
Dogwood, red-osier	*C. stolonifera*				*	*	
Hackberry, dwarf	*Celtis occidentalis pumila*					*	
Honeysuckle, bush	*Diervilla Lonicera*					*	
Hop tree	*Ptelea trifoliata*					*	
Huckleberry	*Gaylussacia baccata*					*	
New Jersey, tea	*Ceanothus americanus*					*	
Rose, wild	*Rosa acicularis*				*	*	
Rose, wild	*R. blanda*				*	*	
Rose, wild	*R. humilis*				*	*	
Sumac, aromatic	*Rhus canadensis*				*	*	
Sumac, dwarf	*R. copallina*				*	*	
Sumac, staghorn	*R. typhina*				*	*	
Viburnum, maple-leaved	*Viburnum acerifolium*						*
Willow, furry	*Salix syrticola*		*	*	*		
Willow, prairie	*S. humilis*			*	*	*	
Willow, smooth	*S. glaucophylla*		*	*	*		
Witchhazel	*Hamamelis virginiana*						*

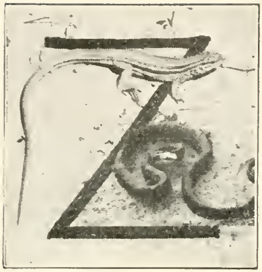
Common Name of Plant	Scientific Name	Beach Assoc.	Fore-Dune Assoc.	Cottonwood Assoc.	Pine Assoc.	Black Oak Assoc.	Mixed Oak Assoc.
Evergreen trees and shrubs							
Arbor Vitae	*Thuja occidentalis*				*		
Cedar, white (*see* Arbor Vitae)							
Cedar, red	*Juniperus virginiana*				*	*	
Juniper, common	*Juniperus communis*				*		
Juniper, prostrate	*J. horizontalis*				*		
Pine, jack	*Pinus Banksiana*				*		
Pine, white	*P. strobus*				*		
Vines							
Bittersweet	*Celastrus scandens*			*	*	*	
Grape, fox	*Vitis vulpina*				*	*	
Grape, summer	*V. aestivalis*				*	*	
Grape, wild	*V. cordifolia*				*	*	
Ivy, poison	*Rhus Toxicodendron*			*	*	*	*
Virginia creeper	*Psedera quinquefolia*				*	*	*
Herbaceous plants—flowering							
Arbutus	*Epigaea repens*				*		
Aster	*Aster linariifolius*				*		*
Aster	*A. sericeus*				*		
Anemone	*Anemone cylindrica*					*	
Beach pea	*Lathyrus maritimus*		*				
Bean, sand	*Strophostyles helvola*		*	*			
Bearberry	*Arctostaphylos Uva-ursi*				*	*	
Bedstraw	*Galium Aparine*						*
Bellwort	*Uvularia grandiflora*				*	*	
Bergamot, wild	*Monarda fistulosa*					*	
Blazing star	*Liatris cylindracea*					*	
Blazing star	*L. scariosa*					*	
Bluebell	*Campanula rotundifolia*				*	*	
Broom rape	*Orobanche fasciculata*		*	*			
Bugseed	*Corispermum hyssopifolium*		*	*			
Butterfly weed	*Asclepias tuberosa*					*	
Cactus (*see* Prickly Pear)							
Checkerberry	*Gaultheria procumbens*				*	*	
Cherry	*P. virginiana*					*	
Cherry, ground	*Physalis lanceolata*			*	*	*	
Cinquefoil, beach	*Potentilla canadensis*		*				
Cinquefoil, shrubby	*P. fruticosa*				*		
Cinquefoil, silver	*P. Anserina*		*				
Clover, bush	*Lespedeza capitata*					*	
Cocklebur	*Xanthium canadense*	*					
Columbine	*Aquilegia canadensis*					*	*
Cranesbill (*see* Geranium)							
Cress, rock	*Arabis lyrata*					*	

Common Name of Plant	Scientific Name	Beach Assoc.	Fore-Dune Assoc.	Cottonwood Assoc.	Pine Assoc.	Black Oak Assoc.	Mixed Oak Assoc.
Dandelion, dwarf	*Krigia amplexicaulis*	....	....	....	....	*	....
Dandelion, dwarf	*K. virginica*	....	....	....	*	*	....
Daisy, yellow	*Rudbeckia hirta*	....	....	....	....	*	....
Evening primrose	*Oenothera biennis*	....	*	....	....	*	....
Evening primrose	*O. rhombipetala*	....	*	....	....	....	....
Everlasting	*Antennaria plantaginifolia*	....	....	....	....	*	....
Foxglove, false	*Gerardia pedicularia*	....	....	....	....	*	....
Frostweed	*Helianthemum canadense*	....	....	....	....	*	*
Geranium	*Geranium carolinianum*	....	....	....	....	*	....
Geranium	*G. maculatum*	....	....	....	....	....	*
Ginseng, dwarf	*Panax trifolium*	....	....	....	....	....	*
Goldenrod	*Solidago nemoralis*	....	....	....	....	*	....
Goldenrod	*S. racemosa*	....	....	....	....	*	....
Goldenrod	*S. rigida*	....	*	*	....	....	....
Goldenrod	*S. speciosa*	....	....	....	....	*	....
Grass, blue stem	*Andropogon scoparius*	....	....	....	*	....	....
Grass, marram	*Ammophila arenaria*	....	*	*	....	....	....
Grass, rye	*Elymus canadensis*	....	*	*	*	....	....
Grass, sand reed	*Calamovilfa longifolia*	....	*	*	....	....	....
Grass, switch	*Panicum virgatum*	....	....	....	....	*	....
Grass, triple awned	*Aristida tuberculosa*	....	....	....	....	*	....
Grass	*Festuca octoflora*	....	....	....	....	*	....
Grass	*Koelaria cristata*	....	....	....	....	*	....
Grass	*Sphenopholis obtusata*	....	....	....	....	*	....
Grass, goose	*Potentilla Anserina*	*	*	....	....	....	....
Grass, star	*Hypoxis hirsuta*	....	....	....	*	....	....
Hepatica	*Hepatica triloba*	....	....	....	....	*	....
Horsemint	*Monarda punctata*	....	....	....	*	*	*
Knotweed, small	*Polygonella articulata*	....	....	....	....	*	*
Lady's-slipper, yellow	*Cypripedium parviflorum*	....	....	....	....	*	*
Lily-of-the-valley, false	*Maianthemum canadense*	....	....	....	*	....	....
Lousewort	*Pedicularis canadensis*	....	....	....	....	*	....
Lupine	*Lupinus perennis*	....	....	....	....	*	....
May apple	*Podophyllum peltatum*	....	....	....	....	*	*
Milkweed, green	*Acerates viridiflora*	....	*	*	....	*	....
Pea, beach	*Lathyrus maritimus*	*	*	....	....	....	....
Pea, hoary	*Tephrosia virginiana*	....	....	....	....	*	....
Phlox, bifid	*Phlox bifida*	....	....	....	....	*	....
Phlox, blue	*P. divaricata*	....	....	....	....	....	*
Phlox, hairy	*P. pilosa*	....	....	....	*	*	*
Pigweed, winged	*Cycloloma atriplicifolium*	....	*	*	....	....	....
Prickly pear	*Opuntia Rafinesquii*	....	....	....	....	*	....
Prince's pine	*Chimaphila umbellata*	....	....	....	*	....	....
Puccoon	*Lithospermum canescens*	....	....	....	*	*	....
Rose, rock	*Hudsonia tomentosa*	....	....	....	....	....	*
Rattlesnake root	*Prenanthes alba*	....	....	....	....	....	*
Russian thistle	*Salsola Kali tenuifolia*	....	....	*	....	*	....
Sarsaparilla	*Aralia nudicaulis*	....	....	....	....	*	*

Common Name of Plant	Scientific Name	Beach Assoc.	Fore-Dune Assoc.	Cottonwood Assoc.	Pine Assoc.	Black Oak Assoc.	Mixed Oak Assoc.
Sea rocket	*Cakile edentula*	*	*	....	....	....	....
Sedge	*Carex eburnea*	....	....	....	....	....	*
Sedge	*C. Mühlenbergii*	....	....	....	....	*	....
Sedge	*C. pennsylvanica*	....	....	....	....	*	....
Sedge	*C. umbellata*	....	....	....	....	*	....
Sedge	*Cyperus filiculmis*	....	....	....	....	*	....
Sedge	*C. Schweinitzii*	....	....	....	....	*	....
Shinleaf	*Pyrola elliptica*	....	....	....	*	*	....
Shinleaf	*P. secunda*	....	....	....	*	....	....
Solomon's seal	*Polygonatum commutatum*	....	....	....	*	*	*
Solomon's seal, false	*Smilacina tellata*	....	....	....	*	*	....
Solomon's seal, false	*S. racemosa*	....	....	....	*	*	....
Spiderwort	*Tradescantia virginiana*	....	....	....	....	*	*
Spurge, seaside	*Euphorbia polygonifolia*	*	*	*	....	....	....
Spurge, flowering	*E. corollata*	....	....	....	....	*	....
St. John's-wort	*Hypericum Kalmianum*	....	....	....	*	*	....
Star flower	*Trientalis americana*	....	....	....	*	....	....
Sunflower	*Helianthus divaricatus*	....	....	....	....	*	....
Sunflower	*H. occidentalis*	....	....	....	....	*	....
Thistle, sand	*Cirsium Pitcheri*	*	*	*	....	....	....
Toadflax	*Linaria canadensis*	....	....	....	....	*	....
Toadflax, bastard	*Comandra umbellata*	....	....	....	....	*	....
Twinflower	*Linnaea borealis*	....	....	....	*	....	....
Violet, arrow-leaved	*Viola sagittata*	....	....	....	....	*	....
Violet, bird's-foot	*V. pedata*	....	....	....	....	*	....
Violet, blue	*V. cucullata*	....	....	....	....	*	*
Violet, Canada	*V. canadensis*	....	....	....	....	....	*
Violet, long-spurred	*V. rostrata*	....	....	....	....	....	*
Wormwood	*Artemisia canadensis*	*	*	*	....	*	....
Wormwood	*A. caudata*	*	*	*	....	*	....
Spore bearers							
Rattlesnake fern	*Botrychium virginianum*	....	....	....	....	....	*
Bracken fern	*Pteris aquilina*	....	....	....	....	*	....
Horsetail fern	*Equisetum arvense*	....	....	*	....	....	....
Scouring rush	*E. hyemale*	....	....	*	....	....	....

CHAPTER VIII

ANIMALS OF THE DUNES



ZONATION of animal forms in the Dunes is quite as evident as that of the plants. This is to be expected since the location of the animals is determined in large measure by their food plants or by nesting sites that in turn are determined by the plants. Before calling attention to some of the characteristic animals of each zone we may give a striking example of the difference in habitat of the several species of the tiger beetles (Fig. 145). The white tiger (*Cicindela lepida*) and the copper tiger (*C. cuprascens*) are abundant in summer along the wet shore just out of reach of the waves where they are busy feeding on small insects washed up from the lake and on the maggots of common flies that live in larger dead animals that are deposited by the same agency. The white tiger flies back to the higher parts of the fore-dune area and to the cottonwood zone to rear its young; in the former area the openings of its burrows are characteristic though not numerous, in the latter, abundant. *Cicindela hirticollis* digs its straight, cylindrical, vertical burrows in which the young are found in the moister parts of the fore-dune area. This species is found foraging very commonly in the cottonwood zone, especially on the landward side of the dunes that border ponds or swales. In the transition belt between cottonwood and pine associations occur the crooked holes of the young and the adults of the large tiger, *C. formosa generosa*. The bronze tiger (*C. scutellaris lecontei*) is characteristic of the pine association itself where it rears its young, and is found also in the adjacent black oak areas, especially in bare sandy spots. Finally, as one travels still farther back from the lake into the oak-hickory association he encounters the green tiger (*C. sexguttata*), though it is much more common still farther back in the hickory-maple and maple-beech forests. Yet other species are confined to the borders of the interdunal ponds (*C. tranquebarica*) to the margins of sphagnum bogs (*C. ancocisconensis*) and to the shores of small lakes (*C. repanda*). It is remarkable that species so closely related should occupy such closely adjacent areas and each keep quite strictly to its own narrow belt. Yet such is found to be the case the world over; closely related species are seldom found living together, but if in the same region each occupies its own restricted area.

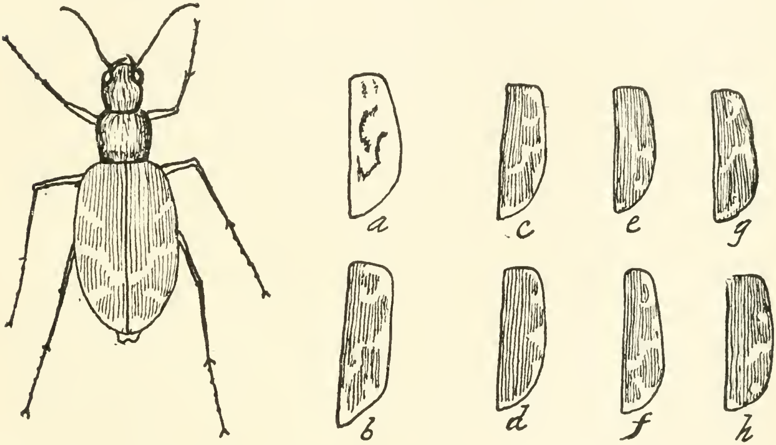


FIG. 145.—Species of tiger beetles. At left, *Cicindela formosa generosa*. *a*, Wing cover of *C. lepida; b, C. cuprascens; c, C. hirticollis; d, C. scutellaris lecontei; e, C. sexguttata; f, C. repanda; g, C. ancocisconensis; h, C. limbalis.* All × 2.

These tiger beetles are all predatory, feeding on flies and other insects which they often capture on the wing. They occur usually on bare, sunny spots. Thus, the green tiger of the maple-beech forest is found on the open paths. They are wary animals, rising in quick flight as you approach and flying in straight lines some distance ahead of you when they turn as they alight to face the intruder. The larva lives in a burrow in which it is supported at the top by a spiny hump; the huge jaws fill the orifice ready to seize any insect that unwarily steps on the living trap. The jaws are approximately ground color so that you are sometimes aware of the presence of the burrows when what was at first solid ground becomes porous as the numerous larvae drop back into their holes on your alarming approach.

That the dune area is prolific in animal life may be realized from the result of an animal census taken in midsummer by Miss Nell Saunders, whereby she found in a mixed area of swale, cottonwoods, and oaks sixteen million animals to the acre. This population was distributed as follows: three-quarters of a million on the ground stratum, three million on the herbaceous plants, ten million on the shrubs, and the remainder on the trees. It is evident from this and from the descriptions to follow that there is a vertical zonation of life as well as a horizontal one.

The succeeding societies of animals beginning with those nearest the shore are, in the Dunes, as follows: (1) The predatory ground beetle association corresponding to the beach association of the plants. (2) The digger wasp association, corresponding to the fore-dune and cottonwood zones. (3) The bronze tiger association corresponding to the transition zone between the cottonwood and pine areas and the pine association. (4) The ant-lion association, equivalent to the black oak plant association. (5) The hylodes association, corresponding to the mixed oak plant zone.

While both the wet beach and the storm beach (Fig. 83) are practically free from plants, they are inhabited by characteristic animals. When a strong offshore wind is blowing, hundreds of species of insects and many birds from the territory adjacent to the lake blow out over the water during their incautious flights and drop exhausted to its surface. When the wind shifts, as it does almost daily, the onshore wind piles these animals, together with dead fish, in long windrows on the beach. Some of the insects survive their prolonged immersion and crawl under stones, chips, and bits of drift on the storm beach. After a storm one may pick up hundreds of species along shore, some of them from regions far inland.

Flesh flies and carrion beetles are to be found feeding on and depositing their eggs in the carcasses of fish and other dead animals. Digger wasps and robber flies are attracted here by the numerous insects that are crawling half-dead from the water. Crows and herring gulls are also drawn by the carrion, the latter are present in great flocks in the fall, fishing offshore as well as feeding along the beach. There are many long-legged shore birds that feed on these insects and on the crustaceans, wading out in the shallow water to hunt them or running along the wet sand. The least and semipalmated sandpipers are fairly common. In spring and fall, particularly the latter, the beach is alive with knots, sanderlings, and turnstones; godwits, curlews, and willets are also often to be noted, while the piping plover is not only found frequently here but occasionally nests in the same area. The Hudsonian curlew, the willet, and the Hudsonian godwit, the latter, especially, becoming rare, are all birds of good size (15 to 17 inches long) with slender bills over 2 inches long. That of the curlew turns down distinctly, a distinguishing feature. The under parts of the willet are white; those of the godwit, chestnut. Knot, sanderling, semipalmated and least sandpipers also have long bills to use as probes. The birds are smaller, however, 10½, 8, 6⅓, and 6 inches long respectively. All are mottled black and gray or buff above. The sanderling has three toes and wing bars; the others, four toes and no wing bars. The small size of the last two serves to make their recognition certain. The breast of the semipalmated is faintly streaked or spotted with black; that of the least, heavily streaked or spotted with brown. The turnstone, which is some 9½ inches long, has a back strikingly mottled in black, brown, and white and a white patch at the base of the tail. The piping plover is small (7 inches), very pale colored, almost ghostlike in its invisibility. The upper parts are ashy;

the under parts, white. There is a black bar on each side of the breast, the two sometimes uniting to form a band across the breast.

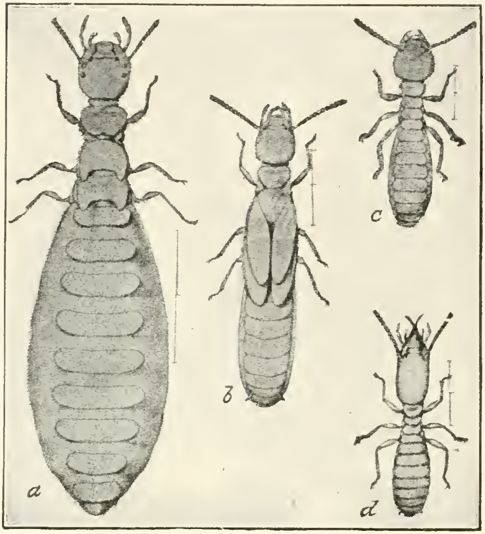


FIG. 146.—Termites or white ants, *Termes flavipes*: *a*, Female; *b*, Male; *c*, Worker; *d*, Soldier. From *Bull. Bureau of Entomology, U.S. Dept. of Agriculture.*

The killdee and semipalmated plovers are also found on the beach, though more characteristic of pastures and marshy uplands respectively. The former is about the size of a robin. It has two black bands crossing its front. It repeatedly whistles "killdee" when disturbed. The latter is smaller (6¾ inches) and has only one black band across its front. The spotted sandpiper is also common, though more characteristic of the shores of streams and smaller inland lakes. It is 7½ inches long, streaked, barred, and spotted all over, the under parts strongly spotted with black on a white ground. It bows and teeters as it comes to a stand.

Under the driftwood of the storm beach one will find hiding by day the common toad, many predatory beetles, an occasional mole or mouse, all-night prowlers that come out in the dusk to feed. Here too one finds the white ants or termites (Fig. 146). The sand-colored spider, *Trochosa cinerea* (Fig. 147), hunts over this territory to good purpose by day.

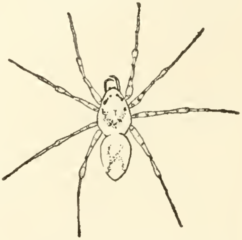


FIG. 147.—The sand-colored spider, *Trochosa cinerea.*

It is difficult to pick out from such a miscellaneous assemblage any particular form by which to name the association. Perhaps it may be called the *predatory ground beetle association* quite justly. Such beetles, including the white and copper tigers, the searcher, a good-sized, bright, bronze-green beetle; the fiery hunter, a black beetle with coppery pits on the elytra (Fig. 148); the yellow-legs, *Galerites janus*, a black beetle with legs and thorax reddish brown, and others are always present, though, in many cases, they are likely blown here from their native haunts farther inland. At any rate they are representative of the whole group of insect-eating animals so characteristic of the zone.

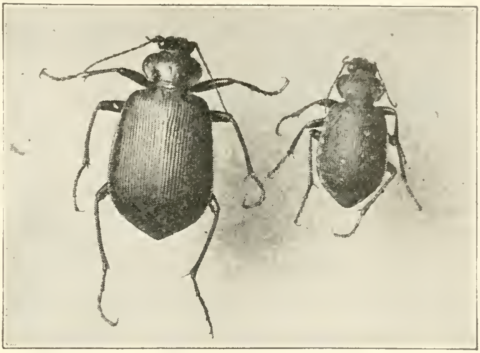


Fig. 148.—The searcher, *Calosoma scrutator*, and the fiery hunter, *C. calidum*.

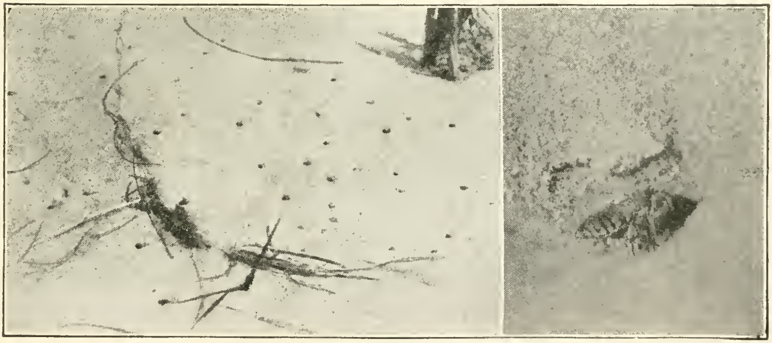


Fig. 149.—Holes of digger wasp, *Microbembex monodonta*, at left; wasp at entrance to hole at right.

The fore-dune zone is intensely hot in summer. The sand burns your bare feet so that it is quite unendurable. Here many inhabitants dig in to get down to the moist, cool sand a few inches below the surface. The burrowing spider does this, coming out at dusk to hunt. Its holes are one-eighth to one-half inch in diameter and 5 or 6 to 20 inches deep. The hole is surrounded in early morning by moist dabs of sand thrown out in excavation. The full-grown spider, legs extended, nearly covers the palm of your hand. It is colored like the sand. Here also the black digger wasp, *Anoplius diversus*, makes its holes in which to rear its young and stocks them with spiders for food for the larvae. The holes are shallow and the heat serves to incubate the eggs. Two other digger wasps of a smaller sort, *Microbembex monodonta* (Fig. 149) and *M. spinulosa* (Fig. 67), or *Bembex spinolae*, excavate holes that are so abundant in spots the surface layer is perforated like a sieve. They are the most strikingly characteristic features of this area and it may properly be designated the *digger wasp association*. Not that the digger wasps are not elsewhere found. But they are nowhere else so conspicuous and dominating a part of the animal consocies. Bee flies (Fig. 150) hover over the groups of wasp holes, dipping down to the surface every once in a while to deposit eggs at the entrance of some wasp hole so that when the latter drags in flies to stock her nest the bee fly egg may be carried in, too. The bee fly larvae live parasitically on the larvae of the digger wasps.

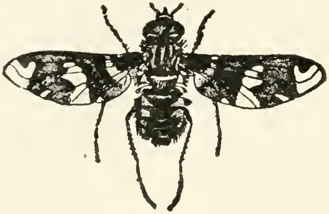


FIG. 150.—The bee fly, *Exoprospa*. After Williston.

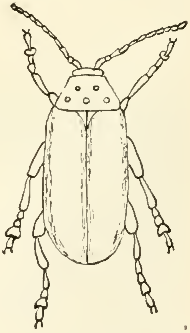


FIG. 151.—The Willow-leaf beetle, *Disonycha quinquevittata*. ×5.

The low plants of the fore-dunes, sand reed, marram grass, sand cherry, smooth and glandular willows, etc., are relatively free from insect pests. Apparently the conditions under which they live are too severe for any but the hardiest of their enemies. The willows are quite free from the willow cone gall. One leaf-eating beetle, *Disonycha quinquevittata* (Fig. 151), is common on them. It is about one-third inch long, yellow with black stripes. There are some aphids on the cherries but the ladybird beetles and syrphus flies keep them well in check. Several snout beetles of the genus *Sphenophorus* (Fig. 152) are very common on the grasses. The larvae feed on the roots of the bunch grass and on the roots of sedges in nearby swales. Gnats and flies that apparently breed down at the shore lodge on these grasses in large numbers. One of the flies has a vigorous bite. The tormented camper in this region may derive some satisfaction from watching the swift darting flight of several species of dragon flies that hunt over and among the clumps of grass and devour many of these flies and gnats. (See next chapter.)

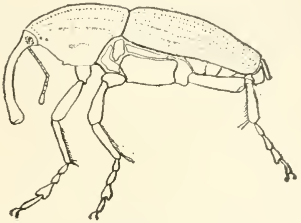


FIG. 152.—A snout beetle, *Sphenophorus*. ×2.

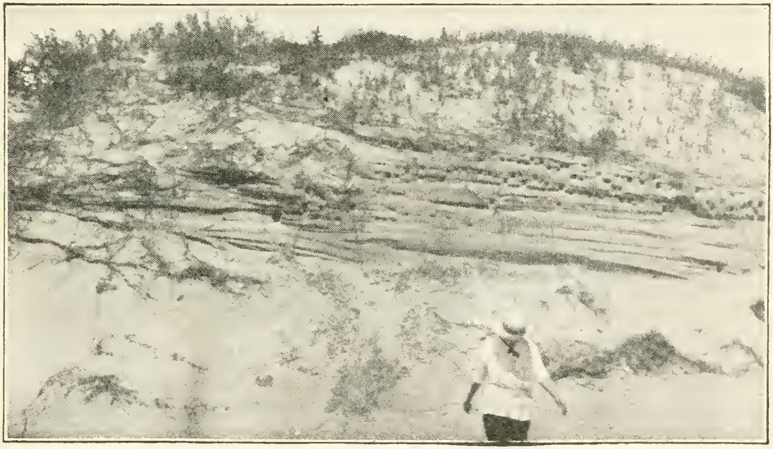


FIG. 153.—Nest holes of bank swallows

In the plant associations there is a sharp demarcation between the fore-dune and the cottonwood zone that comes next, for the cottonwoods add a strikingly new feature. There is no such separation in the animal associations, and both fore-dune and cottonwood areas may be included in the one digger wasp association. True, certain new animals appear. The kingbird finds the tops of the cottonwoods excellent lookouts from which to spy the insects upon which he feeds. But he is more common and more characteristic in other situations as, for instance, along the borders of the woods. The tree swallow nests in the hollow stumps of old pines and cottonwoods. Their backs are iridescent blue green; their throats, breasts, and bellies, pure white. Bank swallows nest in the steep sides of dunes, especially where blow-outs make sand cliffs (Fig. 153). The cottonwood is relatively free from the insect pests that usually accompany it. The cock's comb gall is not frequent on it here. Such a characteristic woodborer of the cottonwood as *Plectrodera scalator* is rare. In the spring when the tree is in blossom certain flies and beetles are attracted by its abundant pollen, but these are also common on the willows of the fore-dune. The white or maritime and long-horned locusts are frequently found in the digger wasp zone, though they are also found in the bronze tiger zone.

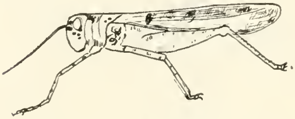


FIG. 154.—Maritime locust, *Trimerotropis maritima.*

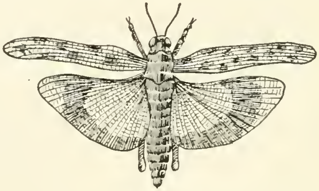
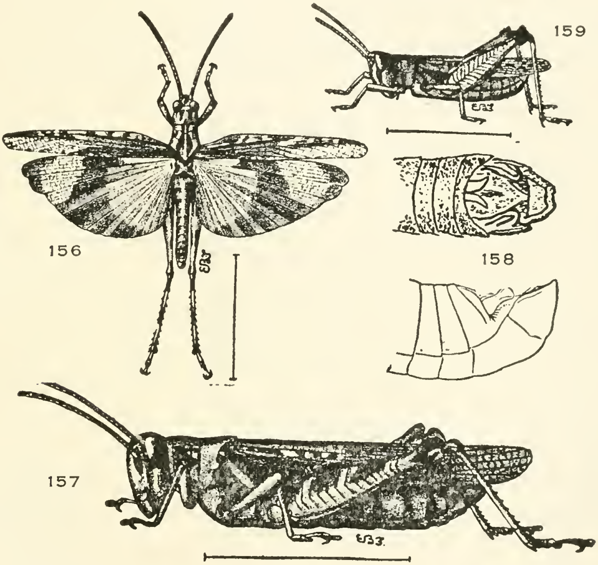


FIG. 155.—Mottled sand locust, *Sparagemon wyomingianum.*

The female of the maritime locust (Fig. 154) is about 1.2 inches long; the male, about .8 of an inch. The animal is light gray to reddish brown in color, the under side almost white. It is so near the color of the sand as to be nearly invisible until it flies. The inner wings have a dark band along the margin but a transparent tip. The inner face of the hind femur bears three black bands. The long-horned locust (Fig. 156) is small, the male two-thirds of an inch long, the female seven-eighths inch. The antennae are half as long as the body, or more. The inner wing has the basal third red, orange, or rarely yellow. The middle third of the wing is covered by a curved black band, the outer third is clear, except for a dusky tip.

Back of the digger wasp association comes the transition stage and the pine association in the plant zonation. Both of these support nearly the same animal population, and it is a very characteristic one. Nowhere else in the Chicago area, unless it be in the sphagnum-tamarack swamps, does one seem to be so far removed from the expected environment. The coniferous trees, the evergreen shrubs, and the herbaceous flowering plants, many of which are quite boreal, are more striking but no more peculiar than the animals encountered.



FIGS. 156–159: Fig. 156.—Long-horned locust, *Psinidia fenestralis*. After Lugger; Fig. 157.—Lesser migratory locust, *Melanoplus atlanis*. After Lugger; Fig. 158.—End of abdomen of male of narrow-winged locust, *Melanoplus angustipennis;* Fig. 159.—Sand locust, *Ageneotettix arenosus*.

As already noted, the bronze tiger beetle (Fig. 145) is here as well as the burrows of its young. Shelford names the whole association from this form, although the adult animal is found quite as commonly back in the next association. Here, too, particularly in the transition area, is the large tiger beetle (Fig. 145). The white ant is abundant under the logs. Digger wasps are still in evidence, though of species different from those of the preceding zone. The black ant, *Lasius niger americanus*, builds its nests in the sand. The mottled sand locust, the migratory locust, the narrow-winged locust, and the sand locust are pretty well confined to this zone. The mottled sand locust (Fig. 155) is small, the female being about 1 inch long, the male .8 of an inch. The inner wings are yellow with a dark, curved median band. The antennae are as long as the hind femur. The tibia is coral red with white rings. The lesser migratory locust (Fig. 157) is also small, about the same size as the preceding. The femur of the hind leg is reddish yellow and bears two oblique dark bars across the upper outer face. The knees are black. The lower part of the face is usually pink. The inner wings are thin and colorless. The narrow-winged locust (Fig. 158) is also small, slightly under an inch. The antennae are shorter than the femur of the hind leg. The hind tibia is pale blue or bright red. The inner wings are transparent and colorless. The sand locust (Fig. 159) is small, the male being .6 of an inch long, the female .8 inch. The animal is dull brown, the hind tibia is bright scarlet with a basal white ring. On the juniper several spiders are found, *Philodromus alaskensis*, *Xysticus formosus*, *Dendry-*

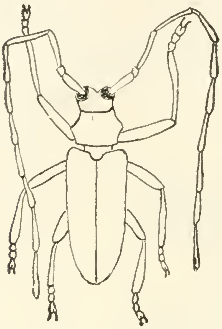


Fig. 160.—Longhorn beetle, *Monohammus scutellatus.*

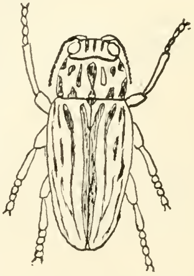


Fig. 161.—Metallic wood-boring beetle, *Chalcophora liberta.*

phantes octavus, Theridium spirale, all small and fairly widely distributed, except the first.

The tree stratum is the one on which the largest number of conspicuous and characteristic forms are found. The pitch moth feeds on the new pine shoots, covering itself in a case of pitch and excreta. Longhorn and metallic wood borers are to be encountered under the bark, or in their tunnels in the wood of the partially dead or wholly dead pines (Figs. 160 and 161). Here, too, one finds certain birds and mammals that are more or less confined to the pines. Downy and hairy woodpeckers nest here. The golden-crowned and ruby-crowned kinglets, the black-throated green warbler, and the pine warbler are abundant during migration. The black-capped chickadee is nearly always present, repeatedly calling his own name. The ruffed grouse is fairly frequent and nests here occasionally or in the adjacent black oaks. The red squirrel that is so constant a feature of the coniferous forests farther north is frequently encountered, as is also the chipmunk (Fig. 162).

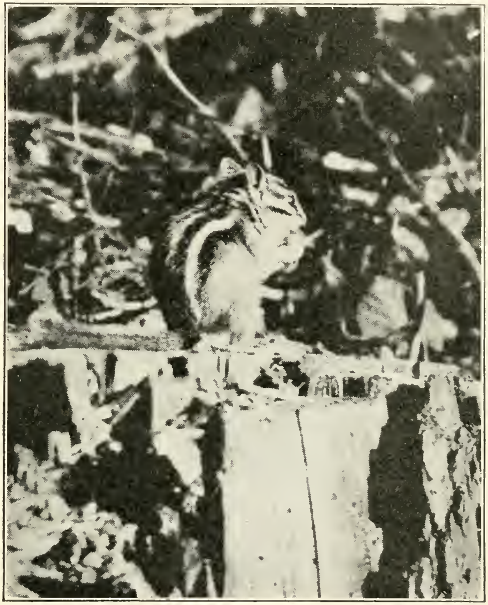


FIG. 162.—Chipmunk, *Tamias striatus griseus*

When the stage is set with the plants of the black oak association the animal dramatis personae change with the changing scenery. This has been designated the ant-lion association.

The conical holes of the young are conspicuous in spots (Fig. 163), though you may travel over these black oak dunes for a long time without encountering them. Still they are confined to the black oak region. The pit is 2 inches or so in diameter and is a crater-like depression in the loose sand. At the bottom under the sand lies the larva, an ugly little duckling. When an ant or other small insect goes on a journey it may step over the edge of such a depression, slide down with the caving sand in spite of its best efforts to escape, and be seized by the jaws of the waiting larva. A grass blade stuck down into the sand at the bottom of the pit will sometimes bring up the larva that fastens its jaws into it and will not let go even when pulled out of its lair. One may go fishing for the tiger beetle larvae in the same way with occasional success. The ant-lion itself is a gauzy winged creature with long body that reminds you somewhat of a very lazy damsel fly. Digger wasps are again present, particularly a big black and orange one (*Ammophila procera*). A curious assemblage of southwestern desert forms are found here on the ground stratum. The cactus (Fig. 60) is a striking plant, particularly if you inadvertently sit down on a patch. The six-lined lizard (Fig. 61) is common in the same locality, and an occasional parokeet is seen on the trees or shrubs (rare).

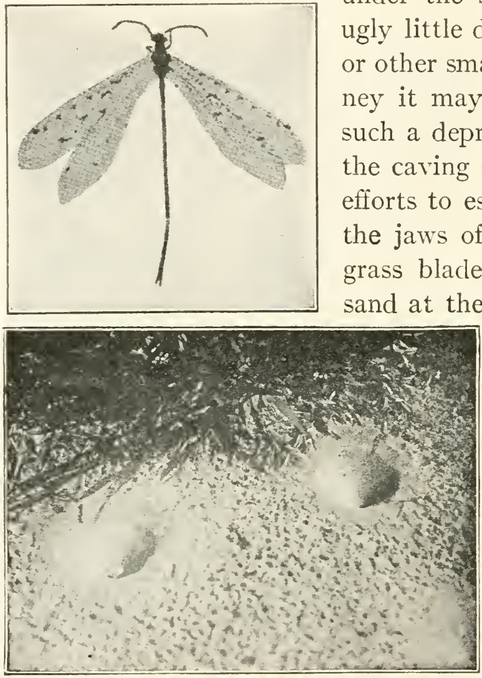
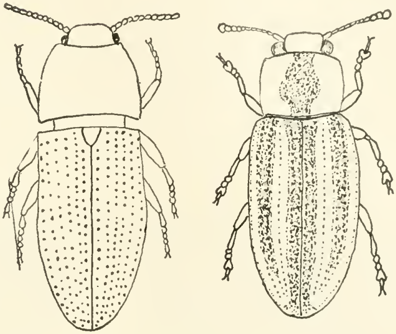


Fig. 163.—Ant-lion, *Myrmelion*, above (after Shelford) and holes of its larvae.

Certain beetles go along with the cactus and are found beneath its leaves, *Lacon rectangularis* (Fig. 164), *Prasocuris phellandrus* (Fig. 165). All these forms even invade the preceding pine or bronze beetle association, and to find the boreal evergreens and attendant northern animals in close juxtaposition to cactus and lizard makes an unwonted contrast. The six-lined lizard lays its eggs in the bronze tiger zone, as does also the blue racer (Fig. 166), but I have found the animals themselves more common in the ant-lion association. Another snake, the hognose or puff adder (Fig. 167), is fairly common in this ant-lion association. It is a mottled animal, a foot or more in length, that spreads and flattens its head into a broad triangle after the manner of the



FIGS. 164–165: Fig. 164.—A click beetle, *Lacon rectangularis*, found beneath cactus; Fig. 165.—A leaf-eating beetle, *Prasocuris phellandrus*, same habitat. Both ×5.

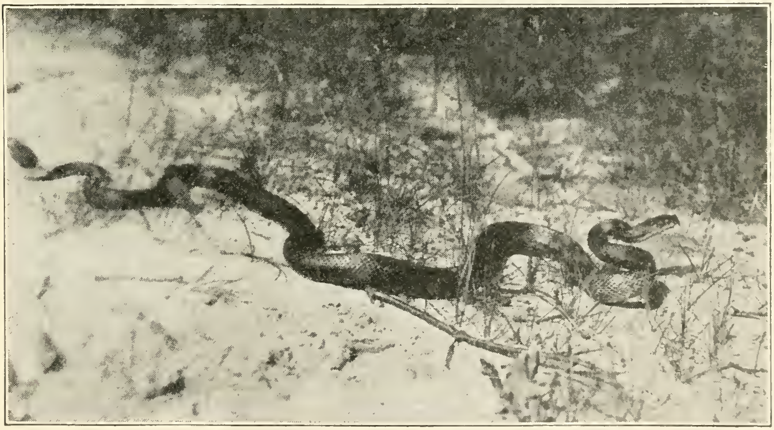


FIG. 166.—Blue racer, *Coluber constrictor*

poisonous snakes when disturbed, though it is quite harmless. If teased it "throws a fit" and lies semi-rigid, belly up, apparently feigning death.

Half a dozen new orthoptera are found on the ground or shrubs in this association: the rusty, leather-colored, sprinkled, and coral-winged locusts, the straight-lance and sword-bearing grasshoppers, the Texan and the forked-tail katydids. The latter two, however, have a very wide distribution and are not therefore at all distinctive of this region. The rusty locust is from .2–.6 inches long. It is russet brown in color with a yellow stripe down the back. It has a bulky body. Its face is vertical. The inner wings are transparent, the tip being slightly red. The leather-colored locust, a closely allied species, is often found associated with it, especially near the margins of the swales, where the latter is often found on the coarse grasses. The rusty locust is stouter than the leather-colored, and its antennae do not exceed .6 of an inch, while in the leather-colored they do, slightly. The sprinkled locust (Fig. 168) is light brown (male) or clay yellow to dark brown (female). The sides of the shieldlike covering of the front part of the thorax bears a glistening black bar in the male, a sprinkling of black spots in the female. The fore wings are sprinkled with dark spots abundantly in the female, sparingly in the male. The coral-winged locust (Fig. 169) is the same size as the preceding, the

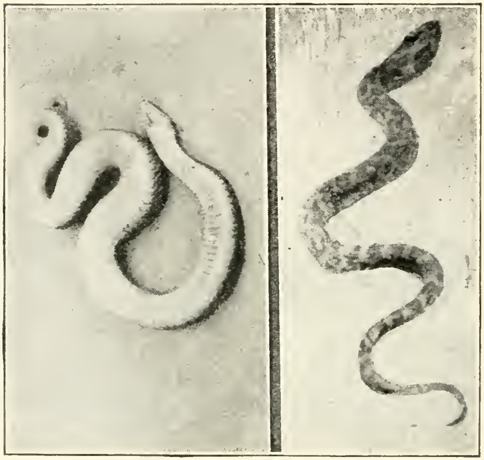
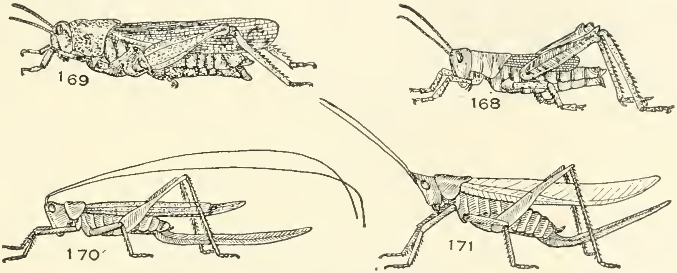


FIG. 167.—Puff adder or hognosed snake, *Heterodon platirhinos*. At left animal is rigid in a "fit."

base of the inner wing is bright coral red. The basal half of the inner face of the hind femur is Prussian blue. The females of the straight-lance and sword-bearing grasshoppers are provided with long ovipositors. In the former (Fig. 170) the ovipositor is longer than the hind femur, and the sides of the body are green. In the latter (Fig. 171) the ovipositor about equals the length of the hind femur, and also the length of the body.

Among the insects no group exhibits more sharply defined zonal limitations than the orthoptera. While some species are cosmopolitan, the majority are found only in definite situations with clearly marked borders that are rarely overstepped. One might name many of the associations with the characteristically present orthoptera. Thus, the digger wasp association might be called the maritime locust association. The bronze tiger association could be quite justly called the narrow-winged locust association, while the ant-lion association might be designated the coral-winged locust association.



FIGS. 168–171: Fig. 168.—Sprinkled locust, *Chloealtis conspersa;* Fig. 169.—Coral-winged locust, *Hippiscus tuberculatus;* Fig. 170.—Straight-lance grasshopper, *Xiphidium strictum;* Fig. 171.—Sword-bearing grasshopper, *Conocephalus ensiger.*

Both in this and the succeeding association the oaks are attacked by gall flies and other gall-forming insects that rear their young in the different sorts of galls induced by their oviposition. Such galls seem to be more abundant on the dunes than elsewhere. Some thirty different sorts can be collected on the oaks in this and the succeeding mixed oak association,

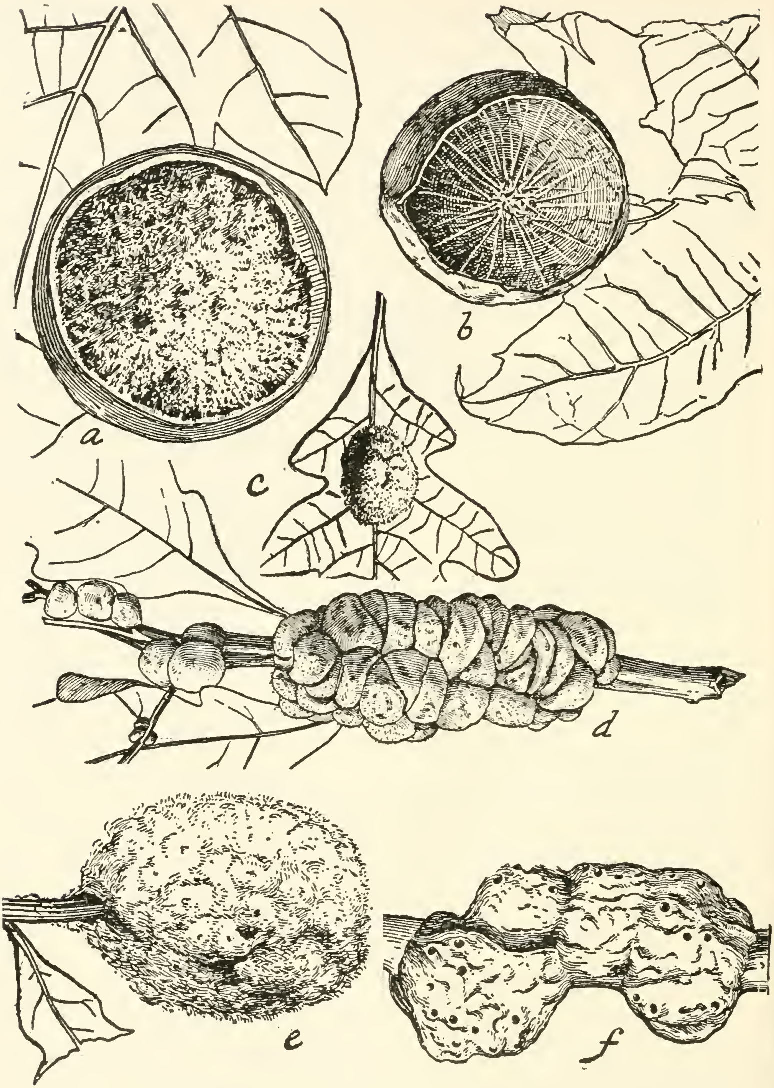


FIG. 172.—Six typical oak galls (from Felt): *a*, Spongy oak apple, *Amphibolips confluentus; b*, Hollow oak apple, *A. inanis; c*, Woolly leaf gall, *Andricus flocci; d*, Oak fig gall, *Biorhiza forticornis; e*, Woolly stem gall, *Callirhytis seminator; f*, Knot gall, *C. punctatus.*

including the oak apple, the empty apple, the petiole gall, the wool gall, the midrib gall, the bullet gall, the seed gall, etc. (Fig. 172).

With the advent of the red and white oaks in the mixed oak association conditions begin to approximate those of the mesophytic climax forests, the oak-hickory and the maple-beech. The soil is well supplied with humus. The shade is deep enough to prevent excessive evaporation and to afford cover for the pioneers of that whole group of animals that belong to the cool, dark, moist recesses of these climax forests. Earth-worms begin to appear. The holes of the woodchuck are common and the mole excavates his subterranean passages. Such snails as *Zonitoides arboreus*, *Polygyra thyroides*, and *P. profunda* are found under the bark of decaying trees, under logs, or crawling on the shrubs in moist weather. They are by no means so common as they are in the later association. Millipedes and centipedes are found under the bark of old logs. The carpenter ant makes its chambers in the decaying logs and stumps, and the aphid housing ants use such passages as stables for their "cows," the plant lice; it carries these through the winter in such sheltered retreats so it can pasture them out in spring on the tender vegetation. Herbaceous plants are now numerous, and there is an abundant insect population on them. Bumblebees, honeybees, and wasps are common. Butterflies are abundant—the monarch, viceroy, spangled fritillary, wood satyr, wood

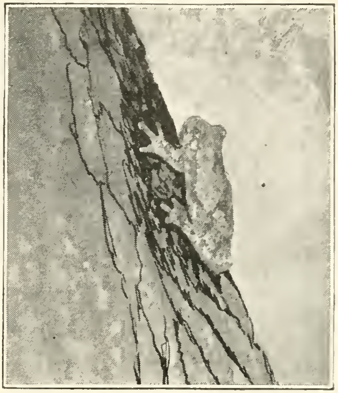


FIG. 173.—Tree toad, *Hyla versicolor*

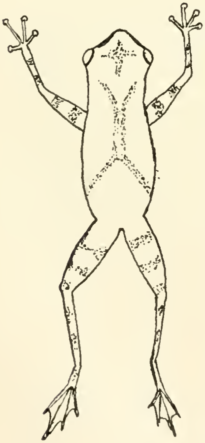


FIG. 174.—Tree toad, *Hyla pickeringii.*

nymph, anglewing, mourning cloak, red admiral, Edward's hairstreak, the zebra swallowtail, and the spicebush swallowtail, etc. The tree frogs, *Hyla versicolor* (Fig. 173) and *H. pickeringii* (Fig. 174), are common on the shrubs and tree trunks. They are so striking an addition with their birdlike peeps that the black oak–red oak association is known on its animal side as the *Hylodes association.* The walking stick is frequently shaken from the foliage of the oak in late summer. The tree cricket, *Oecanthus angustipennis,* and stinkbug are also commonly found on the red oak leaves. The former is a pale green insect with gauzy wings and long antennae with black dots on the basal joints of the antennae. The red-tailed and red-shouldered hawks sail over this territory and nest in the big trees. The red-headed woodpecker, wood pewee, crow, blue jay, bluebird, least flycatcher nest in the trees, and the black and white creeping warbler, the yellow warbler, the wood thrush nest in the shrubs. The gray and fox squirrels are present.

All these animals of the hylodes association, while strikingly new if this zone is entered from the lake side, are old familiars if the area is approached from the other direction, for they are all even more common in the mixed oak–hickory association. The oak-hickory and the maple-beech forests are the climax mesophytic forests and will be considered in a succeeding chapter.

CHAPTER IX

INTERDUNAL PONDS AND TAMARACK SWAMPS

AS THE dunes are a series of sand ridges, more or less parallel to the lake shore, so between them there lies a corresponding series of valleys, often steep sided with interdunal ponds, swales, or swamps (Fig. 175) in their bottoms according as these are low enough to reach or nearly reach the water level. Since the newer dunes are close to the lake, so also are the new interdunal ponds, while those farther and farther back from the lake are of greater and greater age.

Now it is the fate of the permanent pond among the hills to fill up and disappear. Rains wash soils down into it, plants grow in its waters and along its margins, and their accumulating remains fill it with vegetable débris that does not have time to decompose before the next season's luxuriant growth is piled upon it. The black muck at the bottom of the pond rises ever nearer the surface; its lower layers transform to peat. Plants that grow on sandy bottoms are replaced by those that grow on muddy bottoms. Deep-water plants give rise to shallow-water forms. Those plants characteristic of the margins advance toward the center. So the pond transforms to marsh and the marsh to low prairie or wet woodland. (See chap. xi also.) These stages gradually ensuing with the characteristic accompanying plants and animals may each be studied in these interdunal ponds, beginning with those near the shore and working back to the later stages.

Ponds near the lake shore are in a condition similar to the central portions of shallow lakes and ponds farther inland, which portions have not yet been invaded by plants. A little farther back are interdunal ponds stocked with *Chara;* then come others with such plants as *Myriophyllum* and its associates, all forms with finely dissected leaves. These plant populations are similar to the zones shoreward from the bare-bottomed area in shallow lakes. So the successively older dune ponds are comparable to the successive zones of plant and animal forms in the filling inland lakes. The older ponds, if good-sized, will naturally themselves contain several zones, though smaller ones may be completely occupied by the bulrush stage, the cat-tail stage or by similar plants characteristic of some one zone of the larger filling pond.

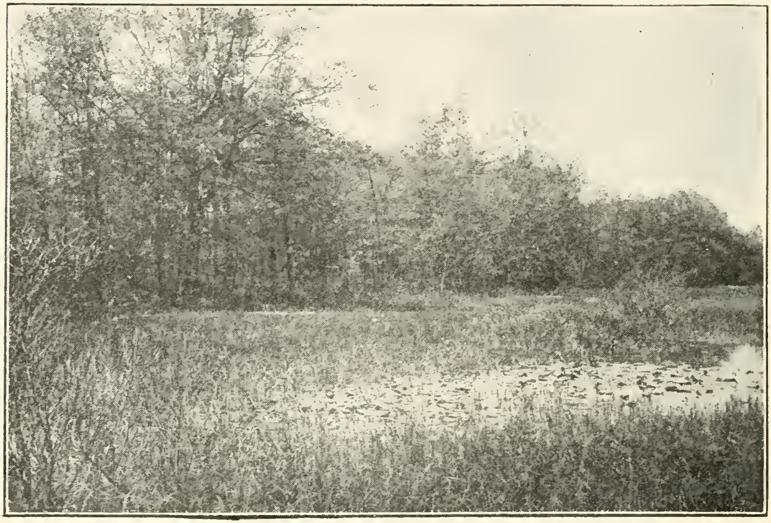


Fig. 175.—Interdunal swale of the first type

The very new pond in the dune region is but a recent cut-off from the lake. Its bottom is sandy; no plants have as yet secured a foothold. There are present a few fish that find its quiet waters good places to lay their eggs; these must find access by some channel connecting with the lake. The fish commonly found in such a pond include the pike, the red horse, the Cayuga minnow, and the shiner. There are also present some clams, notably *Lampsilis luteola*, *Alasmodonta marginata* and *Anadonta grandis*, the first confined to the very new ponds, the other two occurring also in those somewhat older. There are found, too, such insects as the caddis worm (*Goera*) (Fig. 176) nymphs of the damsel flies of the genus *Lestes* and of the dragon flies *Tramea lacerta* and *Celethemis eponina*, the water boatman, and occasional diving beetles that fly, frequently seeking new territory in which to hunt. The caddis-fly, damsel-fly, and dragon-fly nymphs are characteristic, the others cosmopolitan.

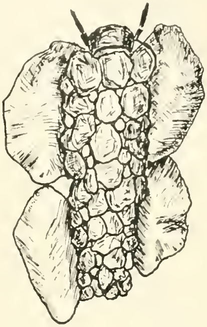


Fig. 176.—Caddis-fly larva, *Goera*. Enlarged.

The damsel-fly nymphs are long, slender, and bear three diverging gill plates at the posterior end of the body. Nymphs of *Lestes* (Fig. 177) are recognized by the form of the so-called accessory jaws (Fig. 178), really labial palps, on the extensible mask of the head, which is the much modified lower lip or labium.

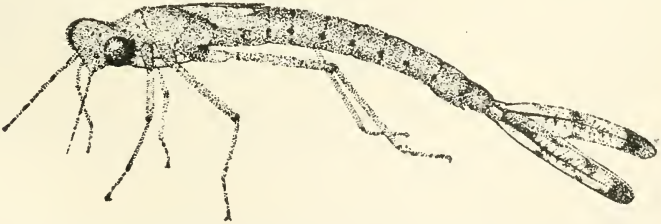


Fig. 177.—Nymph of damsel fly, *Lestes forcipatus*. Enlarged. After Needham

Each "jaw" has two processes, "one of them resembling a fork with the median tines broken off, the remaining process consisting of a long non-bifurcate projection with a short, hairy hook at the distal end and minute teeth along the mesal margin." The nymph of *Tramea lacerta* is green with brown markings. The legs are long and thin. The spines of the eighth and ninth segments are very long. The nymphs of *C. eponina* (Fig. 179) have very prominent eyes, a very large labium, and the abdomen is scarcely narrowed at all until the ninth segment. There is a black band between the eyes and a black band encircling each femur. The adult *Lestes* is rather dull colored, and when it rests, the wings are held as a rule spread horizontally rather than folded over the back, as other damsel flies hold theirs. The full-grown dragon fly of *Tramea lacerta* has a wing-spread of nearly 4 inches. The body is dark, almost black. The upper surface of the abdomen bears white or greenish spots. It flies from June to September. *C. eponina* (Fig. 180) has a wing-spread of about 3 inches. The thorax is red-brown with black stripes. The abdomen is black with yellow spots. The triangle is covered with a spot, and there are two bands, sometimes reduced to spots, on each wing. It also flies from June to September.

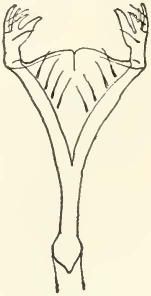


Fig. 178

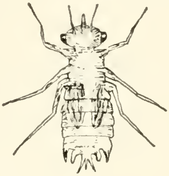


Fig. 179

Figs. 178, 179: Fig. 178.—Jaws of nymph of *Lestes forcipatus*, after Needham; Fig. 179.—Nymph of dragon fly, *Celethemis eponina*.

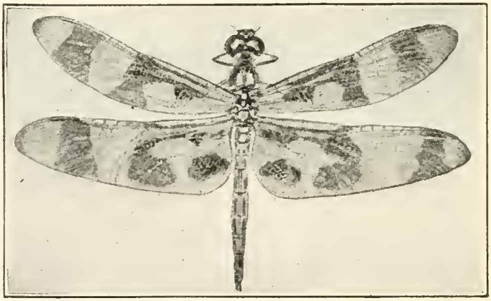
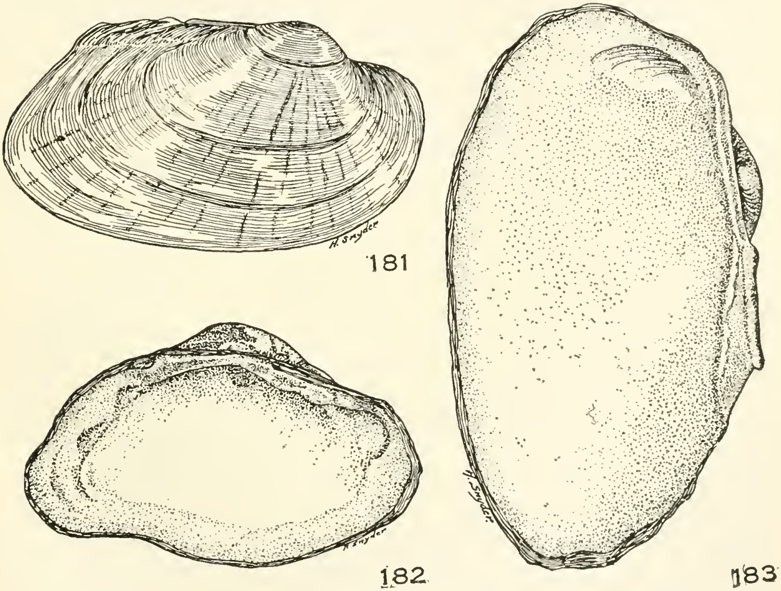


Fig. 180.—Adult dragon fly, *Celethemis eponina*. After Needham.

Lampsilis luteola (Fig. 181) has a smooth shell with distinct narrow green rays. It is about twice as long as high. It is good sized, usually 3-5 inches long and quite thick. The muscle scars and cardinal teeth are plain on the inside of the shell.

Alasmodonta marginata (Fig. 182) is rayed with broad green radiating lines. In outline it is quadrate, the posterior region being truncate. The umbones are marked by three distinct and one feeble double-looped ridges directed forward. It is usually not over 3 inches long. *Anadonta grandis* (Fig. 183) is a large clam 3–7 inches long. The shell is generally thin; the muscle scars are not clear. The color is dark green to black. There may be rays on the young shell. The umbones bear double-looped ridges.

The common pike (Fig. 184) is a slender fish up to 36 inches in length. The head has no scales on its upper portion. The mouth is very large, one-half the length of the head. The red horse is one of the suckers all good-sized fish recognize by the snouty head and the ventral position of the mouth. The lips in this species are strongly plicate. It is a very widely distributed form. The Cayuga minnow and the common shiner are both minnows belonging to the genus *Notropis*. The minnows are usually small, 3–4 inches long, have very large scales in



Figs. 181–183: Fig. 181.—Shell of clam, *Lampsilis luteola;* Fig. 182.—*Alasmodonta marginata;* Fig. 183.—*Anadonta grandis.*

proportion to their size so that there are less than 40 in any one of the rows running the length of the body. The Cayuga minnow is about 2.5 inches long, olivaceous in color. The scales of the lateral line are each marked with a crescentic black area, thus breaking the lateral line into a series of crossbars. The common shiner (Fig. 185) has more than eight rays in the ventral fins. The dorsal fin is either directly over or slightly in front of the ventrals. The color of the fish is olivaceous, silvery below; the males, however, in spring have the sides a rich salmon pink, and in summer the olivaceous has a steel-blue luster.

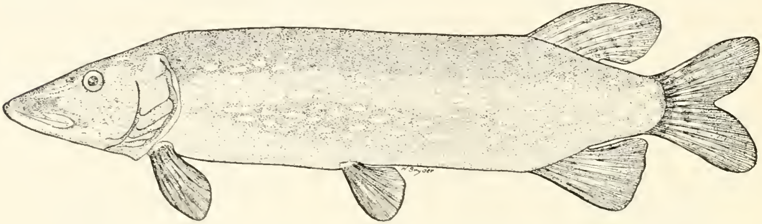


Fig. 184.—The common pike, *Esox lucius*, one-eighth natural size

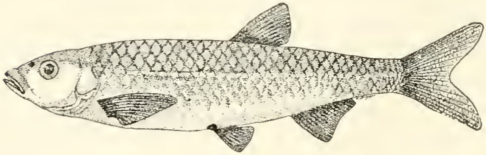


Fig. 185

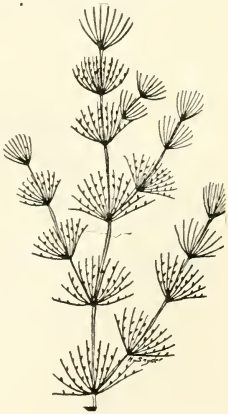


Fig. 186

Figs. 185, 186: Fig. 185.—The shiner, *Notropis atherinoides*, one-half natural size; Fig. 186.—*Chara*, reduced one-half.

The first plant to invade these ponds is usually the chara, an alga with its smaller branches whorled (Fig. 186). It fastens itself to the bottom and grows up in a perfect tangle of green. This plant thrives best in the undrained ponds, but still is found in those with some connection with the lake. It contains in its tissues much silica so that it feels harsh when crushed in the hand, and when pulled out of the pond it has a rank odor. It grows with great rapidity, covering the bottom and growing up in the water, although not to the top. While the chara is getting a foothold and covers the bottom only partially, leaving bare spots, the bluegill (Fig. 187) and pumpkin seed (Fig. 188) are found hiding among its tangles and nesting in the bare places. The clams and caddis flies before mentioned

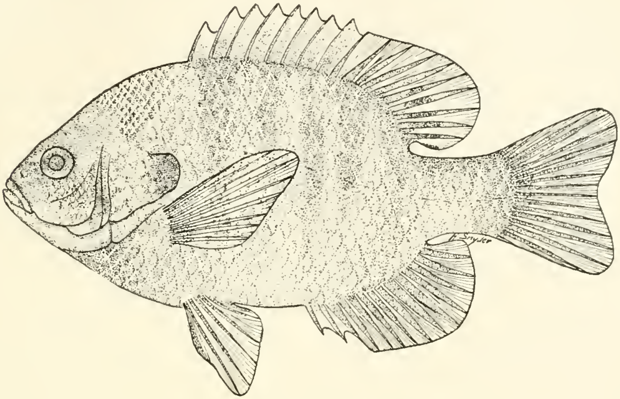


FIG. 187.—The bluegill, *Lepomis pallidus*, reduced one-half

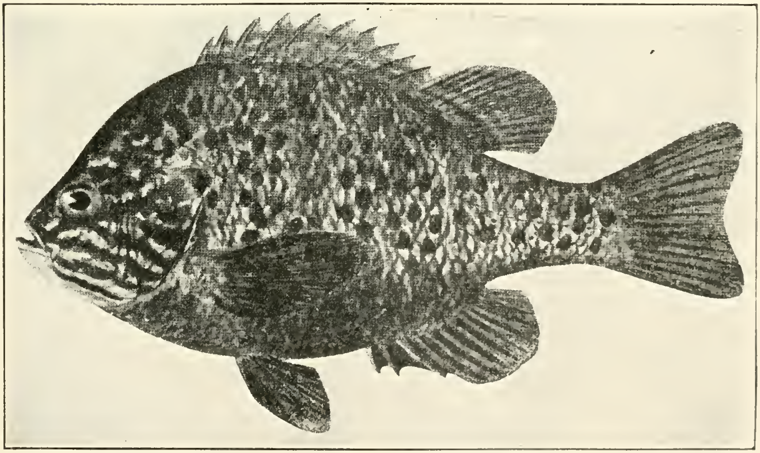


FIG. 188.—Pumpkin seed, *Eupomotis gibbosus*. After Forbes

persist under such conditions. The burrowing dragon-fly nymph (*Gomphus spicatus*) finds the somewhat muddy bottom congenial. As the chara takes complete possession its tangled growth furnishes a safe hiding-place for a new lot of fish—mud minnows, golden shiners, the chub sucker, the bullhead, and the tadpole cat.

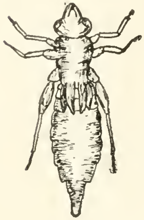


FIG. 189.—Nymph of the dragon fly, *Gomphus spicatus.*

The nymph of *G. spicatus* (Fig. 189) when full grown is over an inch long. The body is flat, hairy on the margins, and the legs are hairy. The abdomen tapers gradually to a point. The color is green, the eyes black. The adult flies in May and June.

The mud minnow (Fig. 190) is about 4 inches long. The upper parts are brownish olive, mottled with black. The sides are barred in dark with bluish intervals, underside yellow, fins olive green. The golden shiner (Fig. 191), also called bream or roach, is 6–8 inches long when full grown. The body is deep, compressed, and tapers both toward head and tail. The head is small. The lateral line sags distinctly. The color is dark olive green. The sides are silvery with golden reflections.

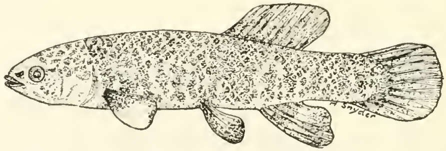


FIG. 190.—Mud minnow, *Umbra limi*, reduced one-half.

In the chub sucker (Fig. 192) the dorsal fin is short and contains from ten to eighteen developed rays. The lateral line is wanting. The adult is only some 10 inches long. The color is brownish-olive, with coppery luster above, paler below. The young are longitudinally striped, the most conspicuous color band being one of purplish black running through the eye and along the side to the caudal fin. Below this the sides shade off to a white or silvery belly.

The bullheads and catfishes have fleshy projectors, "feelers" or barbels about the mouth. The brown bullhead (Fig. 193) has twenty-two or twenty-three rays in the anal fin, including rudimentary ones. It reaches 18 inches in length, though it is usually much smaller. The color is dark yellow-brown to black above, usually mottled; below it is gray, pink, or white. The lower barbels are similarly colored. The black bullhead is found in the older ponds.

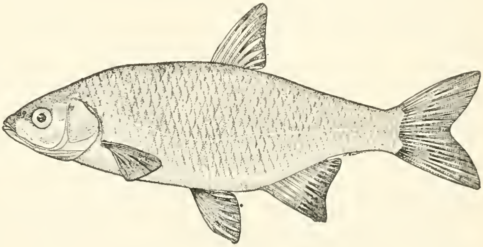


Fig. 191.—Golden shiner, *Abramis crysoleucas*, reduced one-half.

The tadpole cat (Fig. 194) is a small fish, 3–5 inches long, with a thick, fleshy head, so it does have something the shape of a tadpole. It is dark olivaceous above, yellow below. The dorsal fin has a spine at its forward edge, which is more than half the height of the fin.

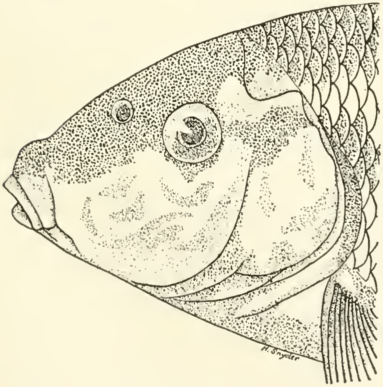


Fig. 192.—Head of chub sucker, *Erimyzon sucetta*.

The chara in the undrained ponds, as well as those in connection with the lake, swarms with the blood-red larvae of *Chironomus*, a midge. These bloodworms crawl upon the plant and build tubes in which they conceal themselves in part. A new caddis-fly larva (*Leptocera*) that builds a long, slender tube of tiny sand grains, replaces the one that was common in the more open chara beds. In the deeper parts of the chara, red water mites, *Limnochares aquaticus* are abundant. Some small snails (*Amnicola limosa* and *A. cincinnatiensis*) are found creeping upon the plants on which larger snails are also frequently present, namely, *Physa gyrina*, known by the left-handed coil of its shell and the fact that the aperture is less than two-thirds the length of the shell, *Lymnaea reflexa* and *Planorbis bicarinatus* (Fig. 324) the former more abundant in the older ponds. *Lymnaea humilis* and *L. desidiosa* are pretty much confined to the younger ponds. *Planorbis parvus*, *P. campanulatus*, *P. hirsutus* are occasionally found in all the relatively newer ponds. Snails of the genus *Amnicola* have small (.3 inch or less) conical shells, the mouth of which is closed when the animal draws back into its shell by a horny close-fitting disk, the operculum. The edge of the opening is not connected with the body of the shell. In *A. cincinnatiensis* the aperture of the shell is nearly half as wide as the shell is long. In *A. limosa* the round opening is pressed quite against the body of the shell which is unusual in the genus. The *Lymnaeas* do not have an operculum. The shell is long with six or so whorls. *L. reflexa* is .8 to 1.6 inches long. The spire is longer than the aperture. The edge of the aperture is strongly turned back. *L. humilis* and

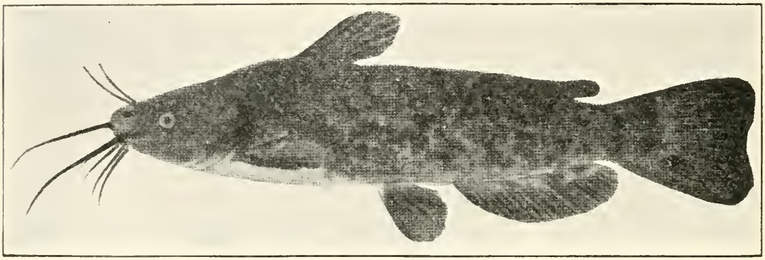


FIG. 193.—Brown or spotted bullhead, *Ameiurus nebulosus*. After Forbes

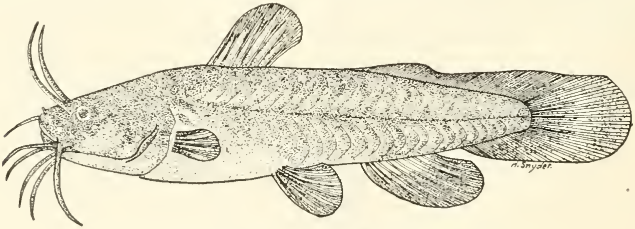


FIG. 194.—Tadpole cat, *Schilbeodes gyrinus*

L. desidosa are small, .6 inch long or less. The former has a short conic spire with an aperture produced below, the latter, a long, tapering spire and the aperture not produced. As the name indicates the whorls of *Planorbis* are in one plane, so the shell is flat. The mouth of the shell flares bell-like in *P. campanulatus*. *P. hirsutus* and *P. parvus* are small, .25 inch or less in diameter. In *hirsutus* the shell is covered with short, bristly hairs. In *P. parvus* both sides of the shell (really top and bottom) are equally concave. A small crustacean, a bender (*Hyalella knickerbockeri*) is abundant, especially in the spring. In general appearance it is much like *Gammarus fasciatus* (Fig. 56), but while *Gammarus* swims on its side constantly, *Hyalella* does

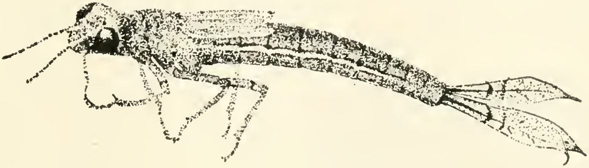


Fig. 195.—Nymph of damsel fly, *Ischnura verticalis*. Enlarged. After Needham

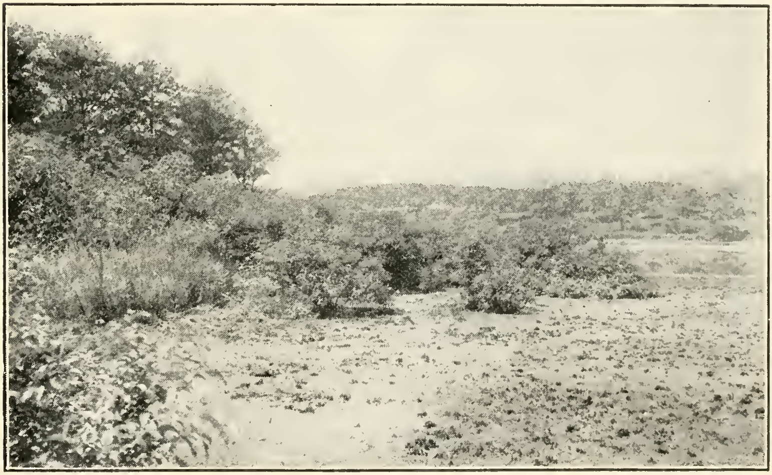


Fig. 196.—Buttonbush, *Cephalanthus occidentalis*, pushing out into pond

so only about half the time, going ventral side up the other half of the time. *Eucrangonyx gracilis* swims on its back all the time. It is found in the old forest ponds. Another crustacean inclosed in a bivalve shell like a small clam is found abundantly on the bottom (*Cypris*, Fig. 56). The musk turtle is a frequent and distinctive inhabitant of these chara ponds. Its odor is quite enough to distinguish it. Chara ponds do not, as a rule, support a varied or abundant animal population, for the chara is not an attractive food plant.

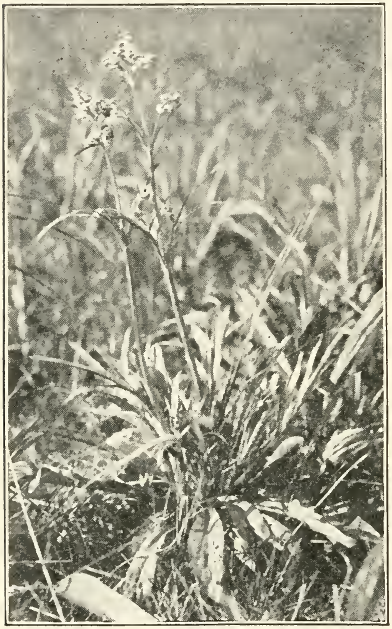


FIG. 197.—Pennsylvania saxifrage, *Saxifraga pennsylvanica.*

As the chara grows and its lower layers decompose, it forms peat rapidly, 1 or 2 inches a year, so that ponds tend to fill up speedily. Then flowering plants, with submerged stems and leaves, the latter much dissected, replace the chara. Their flowers are reared above the surface. Such plants are milfoil, bladderwort, pond weed (Fig. 64), and their associates, to be described more in detail in chapter xi.

The nymph of the damsel fly, *Ischnura verticalis* (Fig. 195), is quite characteristic of these milfoil ponds in the Dunes, though it is a very widely distributed species elsewhere. The nymph may be recognized by the fact that its gill plates end in a long, tapering point and bear one or two dark crescentic crossbands.

The adult male of *Ischnura verticalis* is green with the top of the abdomen black. The females may be either black or orange and they have black spots near the tips of both wings; the fully matured males have the spots on the front wings only. Other forms to be listed below are also found here in the *Myriophyllum* ponds, though not as abundantly as a rule as in the later ponds.

The newer ponds of the dunes may then be described in order, naming them both from the characteristic animals and plants: (1) the *Lampsilis luteolus* ponds or bare-bottomed ponds; (2) bloodworm ponds or *Chara* ponds; (3) *Ischnura verticalis* ponds or bladderwort-milfoil ponds.

The older ponds are usually themselves distinctly zonated and must be described in terms of zonally arranged plant and animal societies rather than as a single society. Yellow and white water lilies appear shoreward from the submerged plants, then come rushes, cat-tails, sedges, and so the filling chara ponds give rise to marshy or swampy areas that seem to evolve into three different types of regions, the differences depending primarily on drainage, namely, (1) the wet forest, (2) the prairie, and (3) the tamarack swamp.

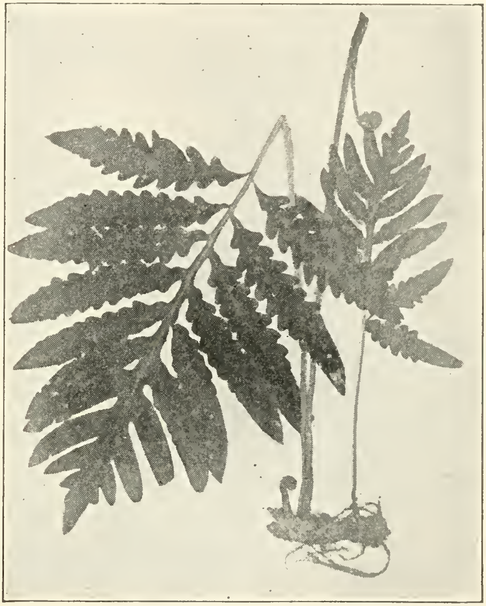


FIG. 198.—The sensitive fern, *Onoclea sensibilis*, underground stem and all.

In the first type (Fig. 175) grasses and sedges grow along the margins, and with them are such plants as the buttonbush, the sensitive fern, marsh marigold, white violet, and the swamp saxifrage. The buttonbush, or elbow bush (Fig. 196), is a low shrub with abruptly bent branches which give it the name elbow bush. It bears large, egg-shaped leaves, rather pointed at both ends. The flowers which are small and white occur in spherical clusters. The marsh marigold or cowslip is familiar to almost everyone. Swamp saxifrage (Fig. 197) has long, slender, lance-shaped leaves that are mostly basal; their borders are toothed. The clustered flowers are yellowish green on long slender stalks. Sensitive fern is so unlike the other ferns of the region that it may be readily recognized from Fig. 198. The leaf is roughly triangular and cut into large lobes, not finely dissected as are most of the fern leaves. It is very sensitive to frost and dies in the early fall.

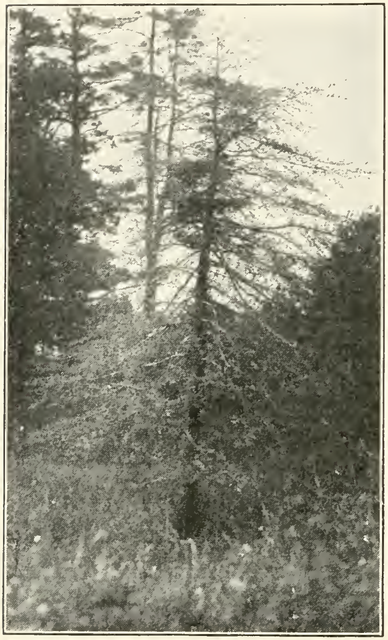
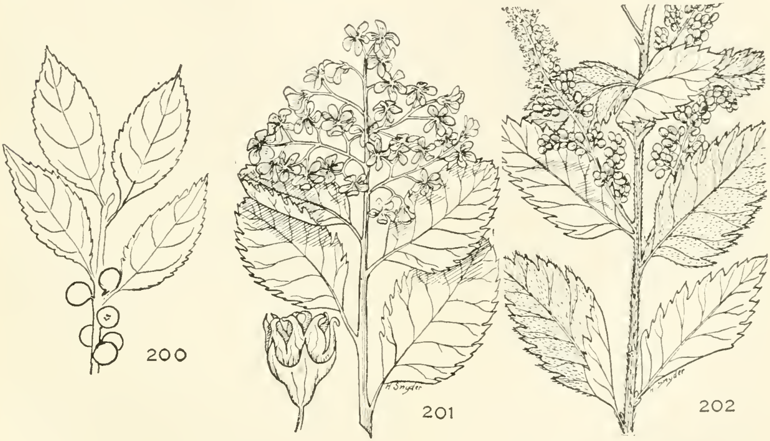


Fig. 199.—Sour gum, *Nyssa sylvatica*

Still farther out on the margin will be found a group of plants that is common at the outer edge of all the marshes—sour gum, the small-toothed trembling poplar, swamp holly, two species of *Spiraea*, the wintergreen, the cinnamon fern, Clayton's fern, and the royal fern.

Sour gum (Fig. 199) is a deciduous tree that has, as a rule, a trunk that runs straight to the top, as does the trunk of a pine. The lower branches droop so that the tree has quite the appearance of a conifer. The small-toothed trembling poplar has the characteristic yellowish-green bark of the poplars. Its leaves are small, finely toothed, and are borne on leafstalks that are vertically flattened. When not in leaf the tree may be recognized by the rounded leaf buds that are smooth. Swamp holly (Fig. 200) is a shrub with alternate simple leaves which are coarsely toothed but not spiny, as is suggested by the name of holly. The fruits are red berries, as in the familiar Christmas holly, but they are not clustered. They grow thickly, however, on the shrub and persist through the early part of the winter.

Spiraea latifolia (Fig. 201), commonly known as meadowsweet, is another low shrub with simple alternate leaves that are lance-shaped and sharply toothed. The flowers, which occur in pyramidal clusters, are pink or pinkish white. *Spiraea tomentosa* (Fig. 202), or steeplebush, is a still more slender shrub, usually unbranched, the stem being covered with silvery hairs. Conical clusters of pink or purplish flowers make it a conspicuous and attractive plant. Clayton's fern, also called the interrupted fern, the cinnamon fern, and the royal fern are closely related species of the genus *Osmunda*. The royal fern (Fig. 203) has leaves that are two or three times compounded. The spore cases are borne at the tips of the leaves. The interrupted fern



FIGS. 200–202: Fig. 200.—Swamp holly, *Ilex verticillata;* Fig. 201.—Meadowsweet, *Spiraea latifolia;* Fig. 202.—Steeplebush, *S. tomentosa.*

(Fig. 204) has a long and rather narrow frond with long and narrow leaflets. Certain leaflets in the middle of the frond are altered to bear the spore cases. The fronds of the cinnamon fern (Fig. 205) are similar to those of the interrupted fern, but have their stalks covered in youth with cinnamon-colored scales. The spore-bearing fronds and the vegetative ones are separate, the former being devoted entirely to the spore cases and appearing quite unlike fern leaves.

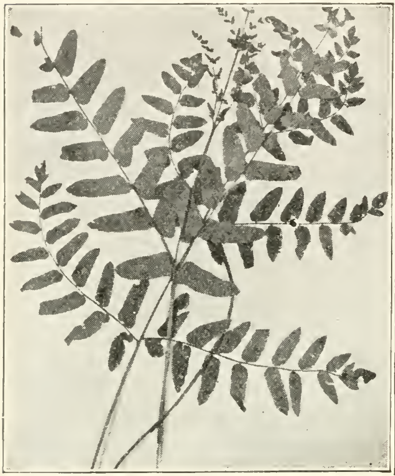


FIG. 203

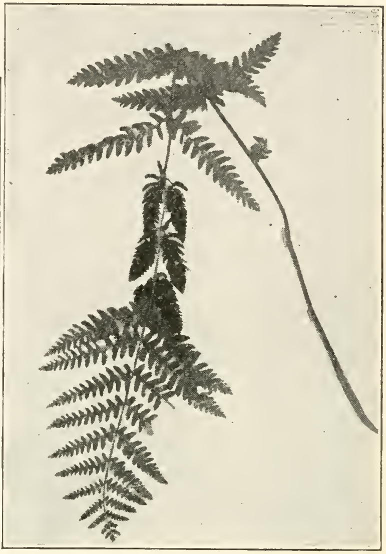


FIG. 204

FIGS. 203, 204: Fig 203.—Royal fern, *Osmunda regalis;* Fig. 204.—Clayton's fern, *Osmunda Claytoniana.*

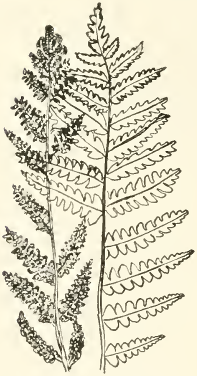


FIG. 205.—Cinnamon fern, *Osmunda cinnamomea*, spore-bearing frond at left.

In the second type of pond (Fig. 206) bulrushes encroach upon the pond lilies, then comes a zone of sedges and grasses and a few willows, mostly the shiny-leaved willow. Still farther shoreward come the iris, the blue-eyed grass (Fig. 102), the yellow-eyed grass, the arrow-leaved violet

(Fig. 131), and the lance-leaved violet, grass-of-Parnassus, and the painted cup. Round the margins in addition to the shiny-leaved willow one finds the red-osier dogwood, the shrubby cinquefoil, and St. John's-wort.

Grass-of-Parnassus has heart-shaped basal leaves 1–2 inches long with five conspicuous veins that run from end to end of the leaf. The flower stalk bears a single conspicuous white flower, bearing several greenish veins. The flower is about an inch in diameter. Painted cup is rather tall and conspicuous because of the bright scarlet bracts among the flowers, giving the plant the appearance of a paintbrush dipped in red paint. Red-osier dogwood is a shrub with bright red stems, quite slender, and very pliable. Shrubby cinquefoil (Fig. 207) is a low, tufted shrub with bark that shreds off readily. The leaves are palmately compound, with five or sometimes seven leaflets. The flowers are yellow, about an inch across.

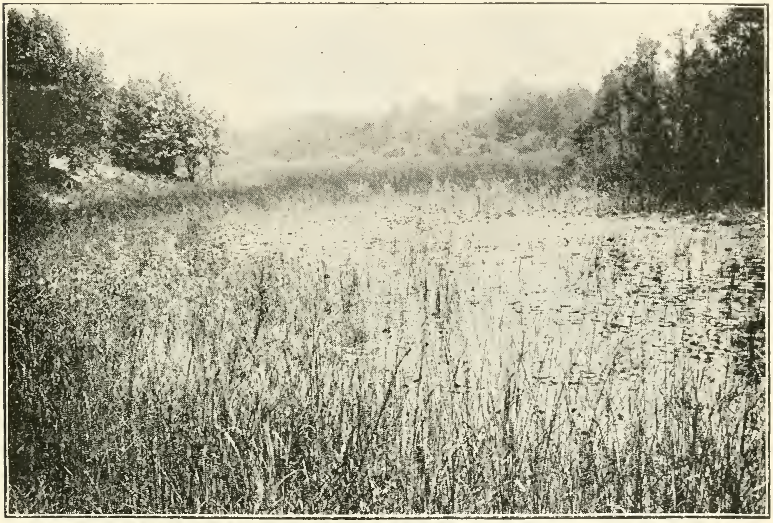


FIG. 206.—Interdunal pond of second type

The animals found in these two types of ponds are practically identical. In the deeper waters are found small clams of the family *Sphaeridae* (Fig. 208). One thinks on first sight that these are the young of the larger clams, but such disappear from the dune ponds with the replacement of the sandy bottom by the muddy bottom. In the *Sphaeridae* the lateral teeth of the shell are found on both sides of the cardinal teeth, while in the larger clams they occur on one side only. A few mud-loving fish are present, like the black bullhead, similar to the spotted (Fig. 193) but dark brownish or greenish

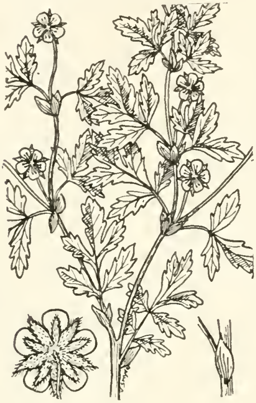


FIG. 207

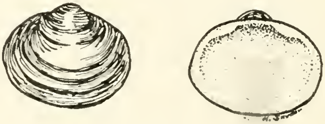


FIG. 208

FIGS. 207, 208: Fig. 207.—Shrubby cinquefoil, *Potentilla fruticosa;* Fig. 208.—A small clam, *Sphacrium simile.*

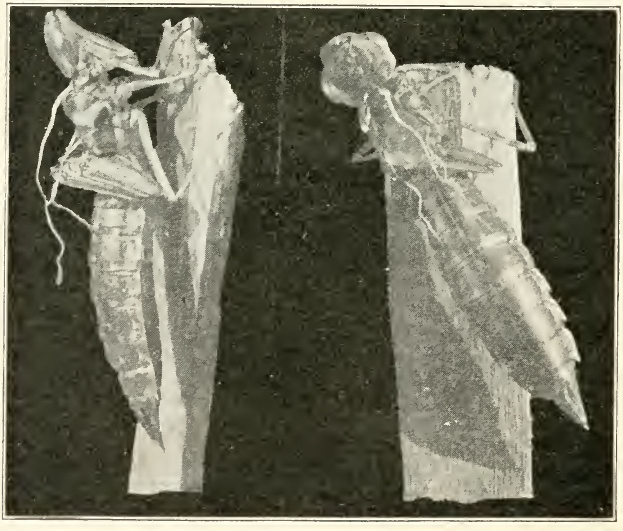


FIG. 209.—Molt skin, nymph of *Anax*

black, unspotted or nearly so. It is our commonest bullhead. The mud minnow (Fig. 190) is also present. Many damsel- and dragon-fly nymphs are present in the marginal zone, and the adults are found hovering over the sedges and grasses. Those of *Libellula pulchella*, *Gomphus spicatus* (Fig. 189), *Leucorhini intacta*, and *Anax junius* occur in the rush and cattail area.

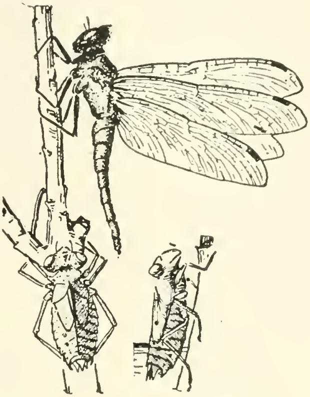


FIG. 210.—Nymph and adult of dragon fly, *Leucorhinia intacta*. After Shelford.

The nymph of *Anax* (Fig. 209) has very large eyes that occupy two-thirds of the side margin of the head. The adult dragon fly appears early in spring, and flies late (late March to mid-October).

The eyes of the adult are very large also, meeting dorsally for some distance. The insect is good sized, the abdomen some 2 inches long. The color is green, marked with brown and blue (male). The front of the face bears a dark spot surrounded by yellow that in turn is encircled with a blue ring.

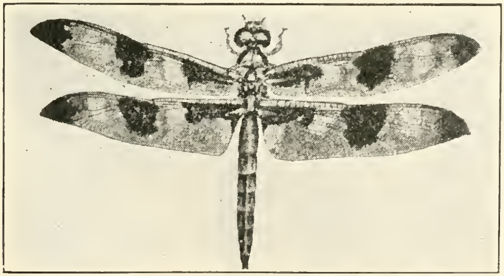


FIG. 211.—Dragon fly, *Libellula pulchella*. After Needham.

The nymph of *L. intacta* (Fig. 210) is mud-colored, flat, and the abdomen terminates abruptly. This is a small species, the adult having a wing-spread of about 2 inches. The body is black. The upper part of the face is ivory white, obscured with yellow in the female. It is commonly known as the white-faced dragon fly. It flies in May and June.

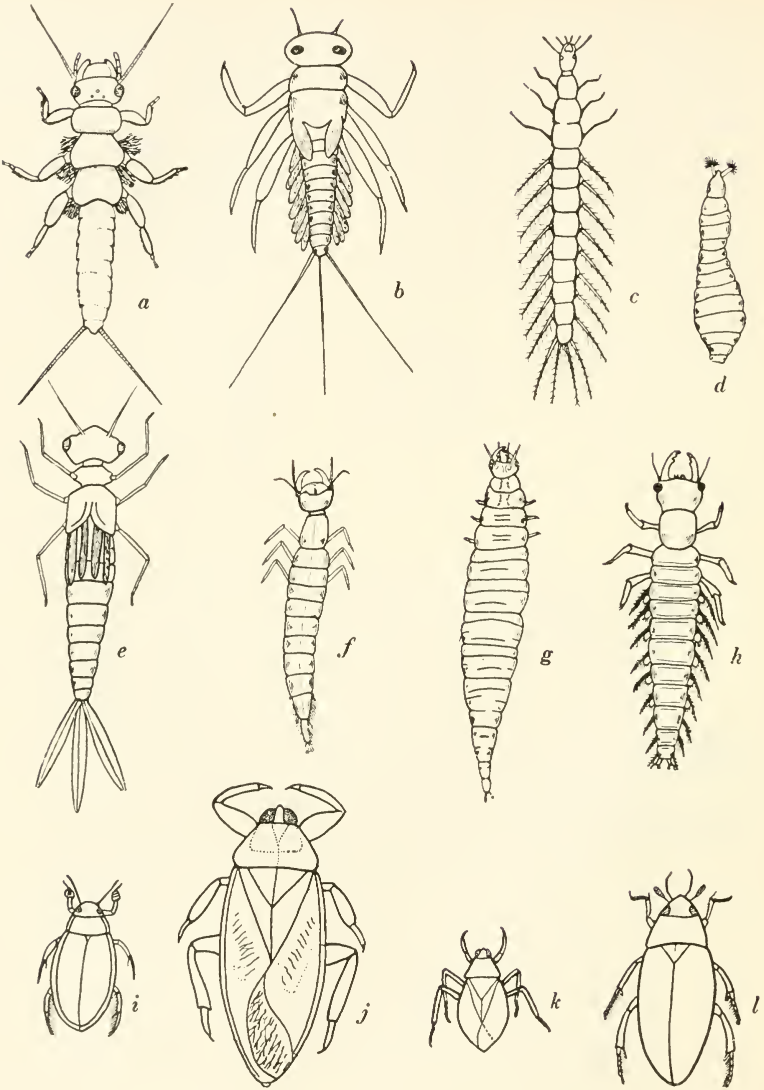


FIG. 212A.—Some aquatic insects and nymphs. After P. S. Welch. *a*, stone-fly nymph; *b*, May-fly nymph; *c*, whirligig beetle larva; *d*, black-fly larva; *e*, damsel-fly nymph; *f*, water tiger; *g*, larva of water scavenger; *h*, the dobson; *i*, diving beetle; *j*, giant waterbug; *k*, smaller waterbug; *l*, water-scavenger beetle.

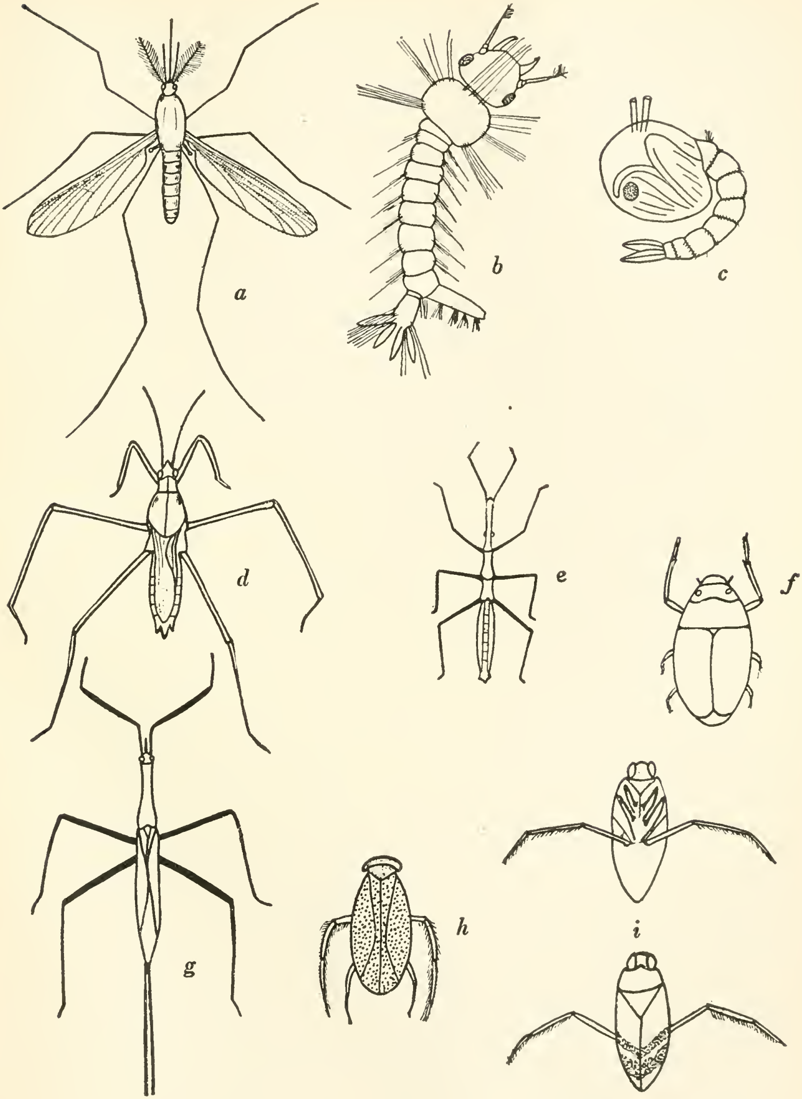


FIG. 212B.—Aquatic insects and nymphs. After P. S. Welch. *a*, adult mosquito, *b*, its larva; *c*, its pupa; *d*, water skater; *e*, marsh strider; *f*, whirligig beetle; *g*, water scorpion; *h*, water boatman; *i*, back swimmer.

In *L. pulchella* the mask covers the most of face in the nymphs; there is but a single median tooth on its median lobe. The adult is (Fig. 211) dark brown to black with two wide green stripes on each side of the thorax and one on each side of the abdomen. The triangle of both fore and hind wings is colored dark; in the front wing its long axis is at right angles to the long axis of wing (July-August).

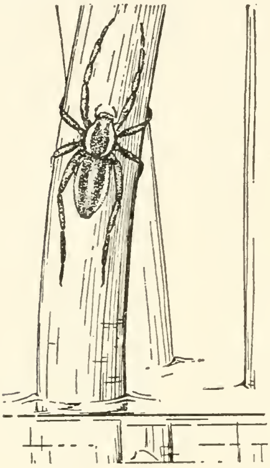


Fig. 213.—The diving spider, *Dolomedes sexpunctatus*. After Shelford.

Electric-light bugs or waterbugs, both great and small, water boatmen, back swimmers and diving beetles, all on Fig. 212, A and B, are numerous. The six-lined diving spider (Fig. 213) is common on the bulrushes. The common pond snail (*Lymnaea reflexa*) is very abundant, as are also two of the flat snails, *Planorbis campanulatus* and *Planorbis parvus*. In the waters of such ponds one will frequently dredge out many of the little efts, *Diemictylus viridescens* (Fig. 214). In the bulrush zone and farther back among the low shrubs the large garden spider (Fig. 215) builds its orb-shaped webs in the summer.

In the late summer the margins of such ponds and swamps are alive with grasshoppers and their kind, whose stridulations are incessant in such a location. Earlier in the season the grouse locusts have had their day. They are small animals, less than .5 inch long. *Tettix granulatus* (Fig. 216) is moderately slender, while the others have heavy bodies. *Tettigidea armata* and *T. parvipennis* were common; *T. lateralis* rare. The figure of *T. lateralis* is given in Fig. 216. *T. parvipennis* is much like it, but the middle joints of the antennae are less than three times as long as wide, while in *T. lateralis* they are more. *T. armata* has the front margin of the thorax (pronotum) extending in a point between the eyes nearly to their fronts, while in the other two species mentioned it does not come out to the mid-eye.

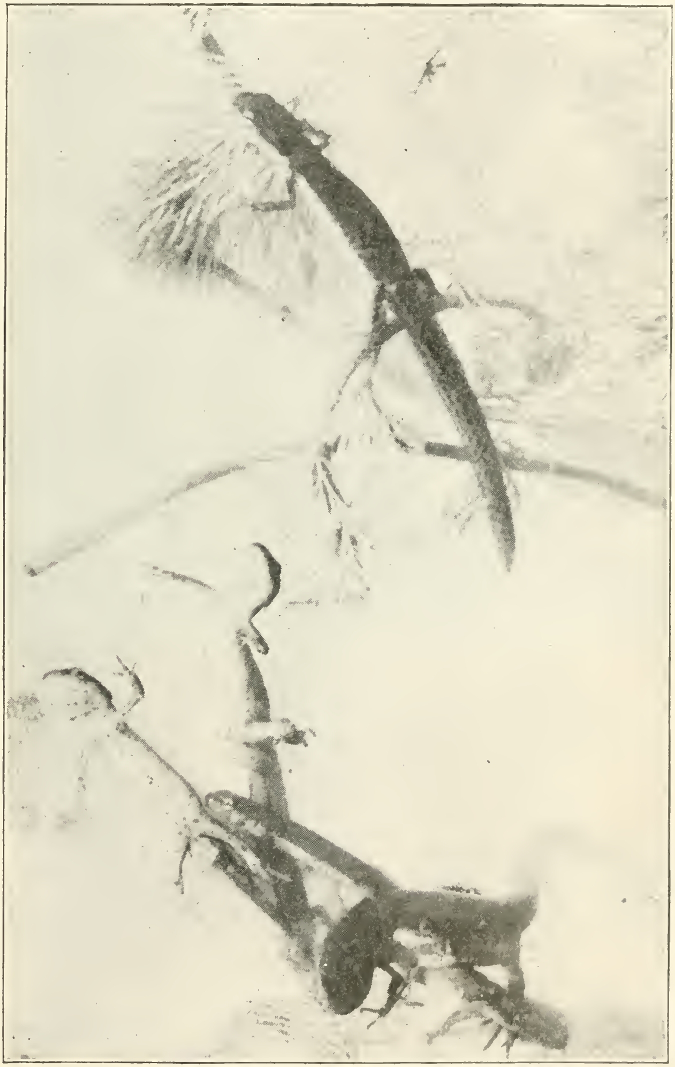


FIG. 214.—The eft, *Diemictylus viridescens*

Now the ascendant forms on the rushes, sedges, and shrubs at the pond margins and in the swales are the short-horned locust; the short-winged green locust (*Dichromorpha viridus*); the slender-bodied locust—rare—(Fig. 219); the Hoosier locust (July); Scudder's paroxya (August); the leather-colored locust; the Nebraska locust; a striped ground cricket and the marsh conehead (Fig. 225). The short-horned locust (Fig. 217) is fairly good-sized, the male measuring .8 inch

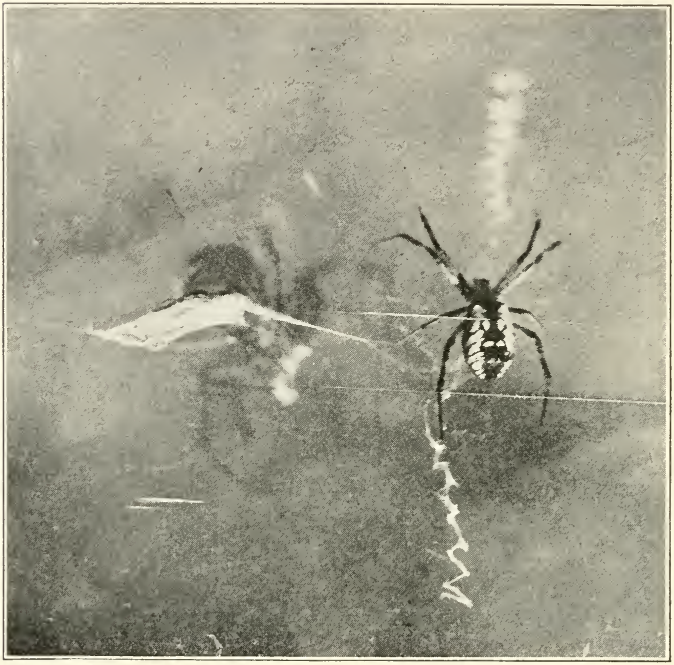


FIG. 215.—Garden spider, the orb builder, *Argiope*

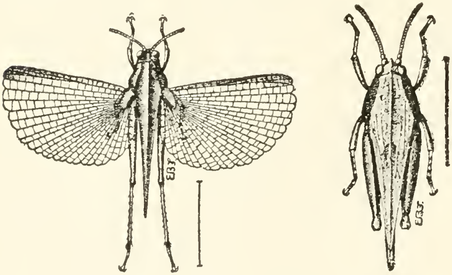
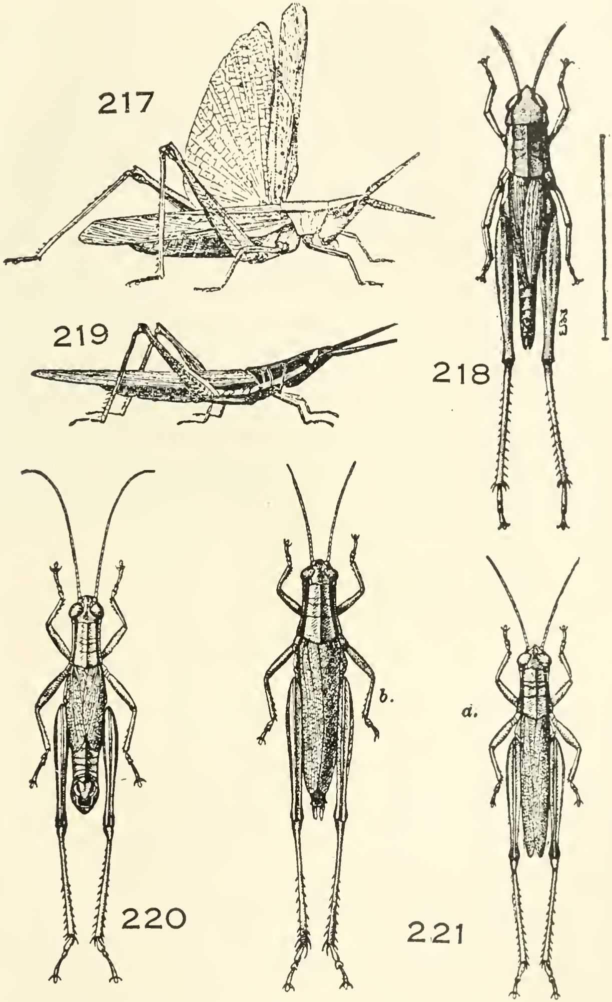


FIG. 216.—The grouse locusts, *Tettix granulatus* and *Tettigidea lateralis*. After Lugger.

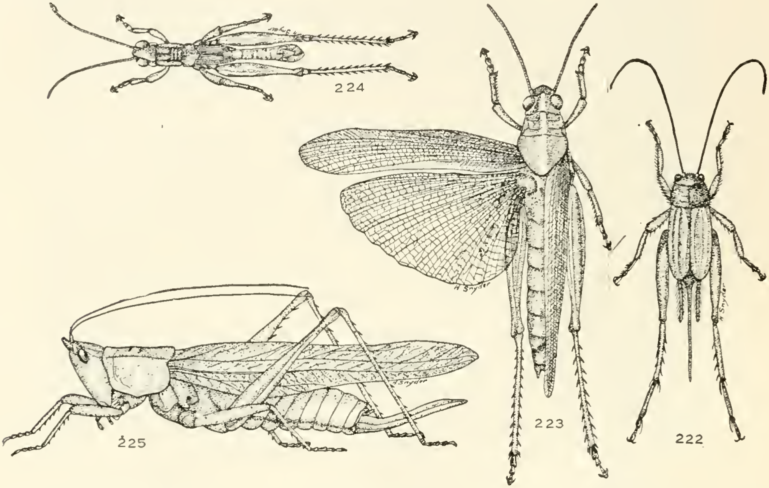
in length; the female, 1.3 inches. They are bright green mottled with brown, the brown sometimes being greatly increased



FIGS. 217–221: Fig. 217.—The short-horned locust, *Tryxalis brevicornis;* Fig. 218.—The short-winged green locust, *Dichromorpha viridus;* Fig. 219.—The slender-bodied locust, *Leptysma marginicollis;* Fig. 220.—The Hoosier locust, *Paroxya hoosieri;* Fig. 221.—Scudder's paroxya, *P. scudderi*, male (*a*), female (*b*). All after Blatchley.

so as to be the dominant color. The antennae are strongly flattened at the base. The mature insects are found from August to late fall.

The short-winged green locust (Fig. 218) is also green marked with brown, or brown with green markings. It is smaller than the preceding, the male being about .6 of an inch long; the female, slightly over an inch. The adults are found as early as mid-July.



Figs. 222–225: Fig. 222.—Striped ground cricket, *Nemobius fasciatus;* Fig. 223.—Leather-colored locust, *Schistocerca alutacea;* Fig. 224.—Nebraska locust, *Phaetaliotes nebrascensis;* Fig. 225.—Marsh conehead, *Conocephalus palustris.*

The male of the Hoosier locust (Fig. 220) is quite brightly colored. The face is green, the mouth parts, yellow. The antennae are reddish brown. The rest of the animal is green, yellow, and black. The female is more dully colored. The latter is 1.25 inches long, the male not quite an inch long. The antennae are very long.

Scudder's paroxya (Fig. 221) is small. The female is less than 1 inch in length; the male, .6 of an inch. The general color is brown with green-yellow markings. An ivory-white line extends back from the eye; above it a broad black band.

The leather-colored locust (Fig. 223) is yellowish brown to olive, and a narrow bright yellow line runs over the middle of the head and down the back. The male is 1.25 inches long; the female, nearly 2 inches.

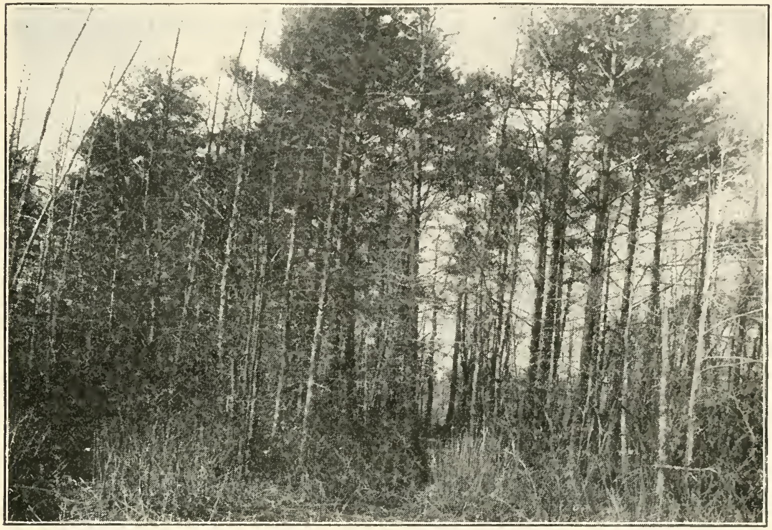


Fig. 226.—A sphagnum bog, tamaracks at margin

The Nebraska locust (Fig. 224) has a slender body, a large head. It is olive green marked with reddish brown; a broad black band extends back from each eye. The male is slightly less than an inch; the female, slightly more than an inch in length.

The striped ground crickets (Fig. 222) are only about .4 of an inch long, brown in color, with dark stripes lengthwise on the head. They are very plentiful and are out feeding by day.

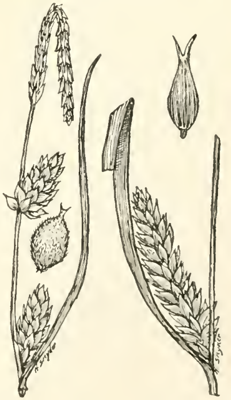


Fig. 227 Fig. 228

Figs. 227, 228: Fig. 227—The slender sedge, *Carex filiformis;* Fig. 228.—The shore sedge, *C. riparia.*

The third type of swamp found in the dune region is the sphagnum bog with its associated border of tamaracks (Fig. 226). It is one of the most striking associations of plants and animals to be found in the

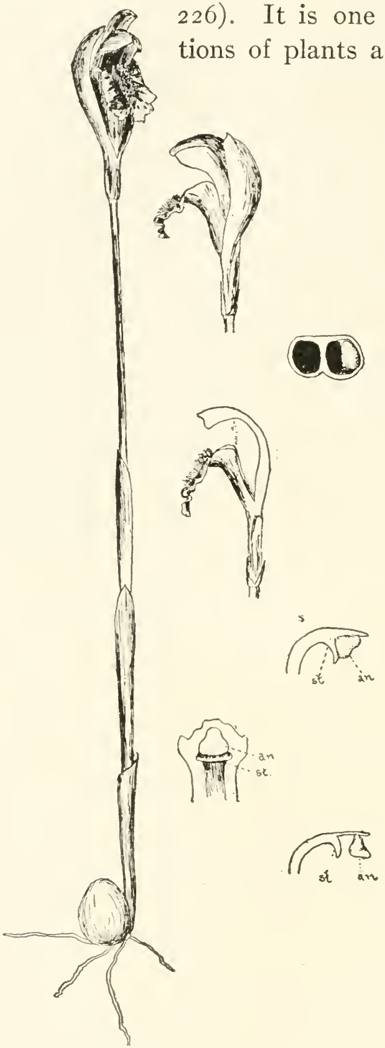


FIG. 229

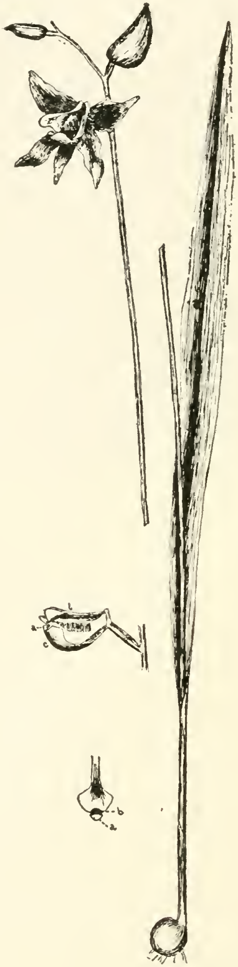
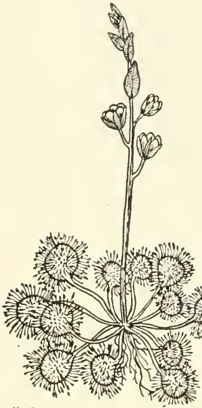


FIG. 230

FIGS. 229, 230: Fig. 229.—The orchis, *Arethusa bulbosa;* details of blossom at right. Drawing by L. N. Johnson; Fig. 230.—The bearded orchis or grass pink, *Calapogon pulchellus.* Drawing by L. N. Johnson.

Chicago area. It is, furthermore, a widely distributed association found at its best in northern North America and Eurasia covering very wide areas. The sphagnum bogs found as far south as the Chicago area are isolated areas—islands in the midst of the more typical associations. As will be seen in a later chapter they are probably remnants of the vegetation that was quite widespread in this region immediately following the glacial period.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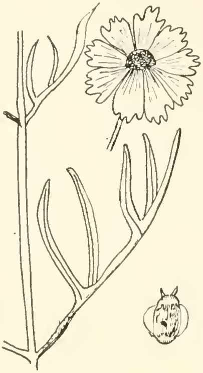
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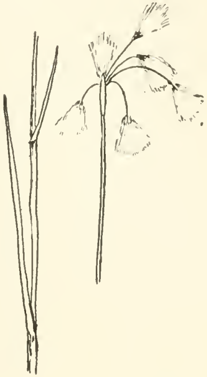
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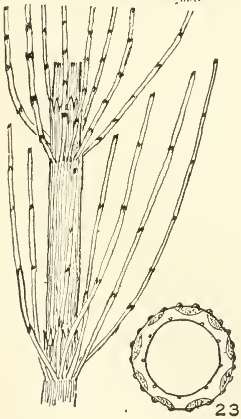
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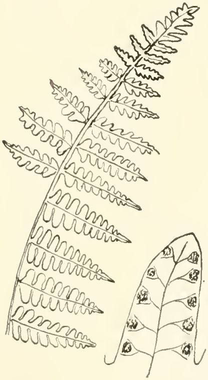
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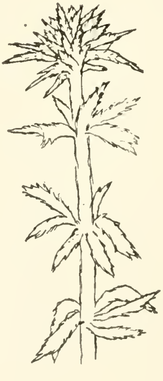
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FIGS. 231–236: Fig. 231.—The sundew, *Drosera rotundifolia;* Fig. 232.—Tickseed, *Coreopsis grandiflora;* Fig. 233.—Cottony grass, *Eriophorum gracile;* Fig. 234.—Swamp horsetail, *Equisetum fluviatile*, and section of stalk; Fig. 235.—Swamp fern, *Aspidium Thelypteris*, and under side of one pinnule; Fig. 236.—Sphagnum moss.

In the center of such a sphagnum bog is frequently found a small lake that is filling, and this may be occupied in part by chara (Fig. 186). Quite commonly the lake, if it is sufficiently deep, will have, shoreward from the chara zone, a zone of water lilies, first the white, then the yellow. The water shield is commonly found growing with the white water lilies. Next comes a zone of floating sedges, the rhizomes of which mat together so densely as to form quite substantial footing. This zone of floating sedges pushes farther and farther out into the lake as ice might form at the margin of a pond. The chief mat-forming sedge is *Carex filiformis* (Fig. 227). The shore sedge, *Carex riparia*

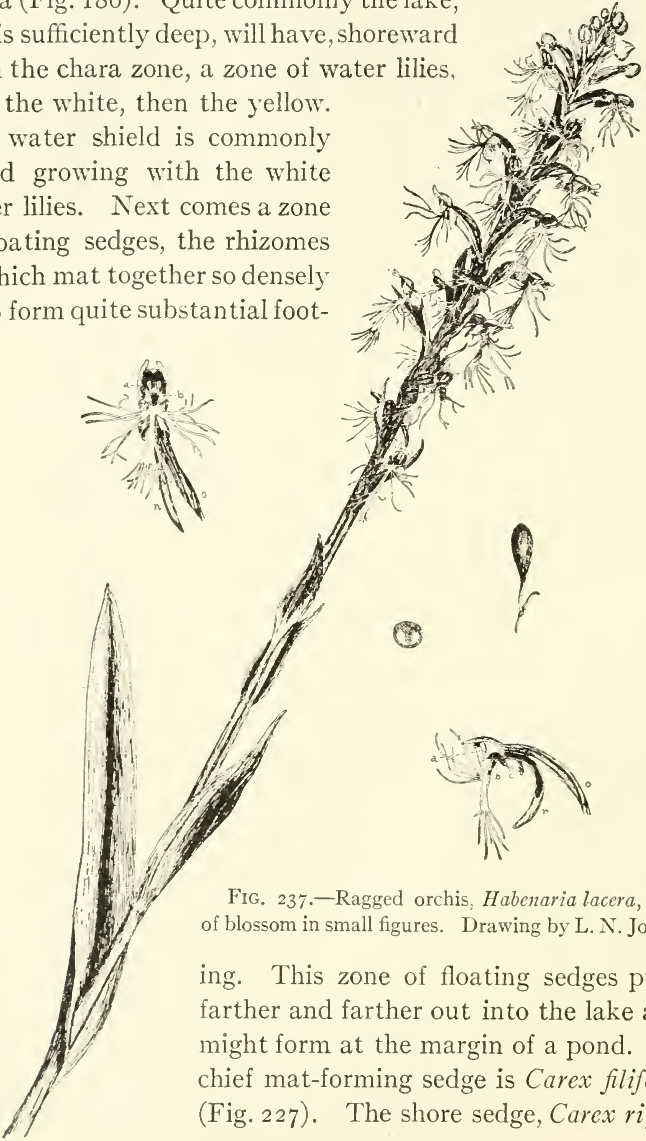


FIG. 237.—Ragged orchis, *Habenaria lacera*, details of blossom in small figures. Drawing by L. N. Johnson.

(Fig. 228), is often found associated with it. Beyond the outer edge of the sedge mat one often finds bladderwort (Fig. 64) growing in the water. As one walks over this sedge mat the surface heaves up and down as if one were walking on rubber ice. In places where the sedge mat is thin, cat-tails are likely to be growing. Farther back toward shore where the sedge mat rests on the peaty soil a number of characteristic plants are to be found. The orchids are present, especially *Arethusa bulbosa* (Fig. 229) and the grass pink, *Calapogon pulchellus* (Fig. 230). The sun dew, *Drosera rotundifolia* (Fig. 231) is a small but striking plant. The little round leaves are covered with upright glandular hairs, at the tip of each of which is a drop of sticky substance sparkling like dew. This leaf is an insect trap. When the insect alights upon it, it sticks as it would to fly paper. The leaf then closes, the tips of the hairs are pressed against the body, the animal is digested, and the plant feeds upon the absorbed organic material. The other plants of this same association are the swamp milkweed, known by its milky juice and flowers like the other milkweeds, the marsh bellflower, tickseed, *Coreopsis grandiflora* (Fig. 232), cottony grass (Fig. 233), swamp

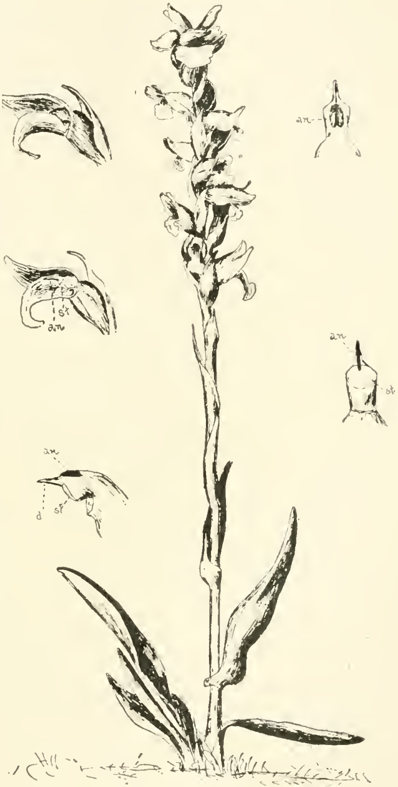


FIG. 238.—Fragrant ladies'-tresses, *Spiranthes Romanzoffiana* (details in small figures.) Drawing by L. N. Johnson.

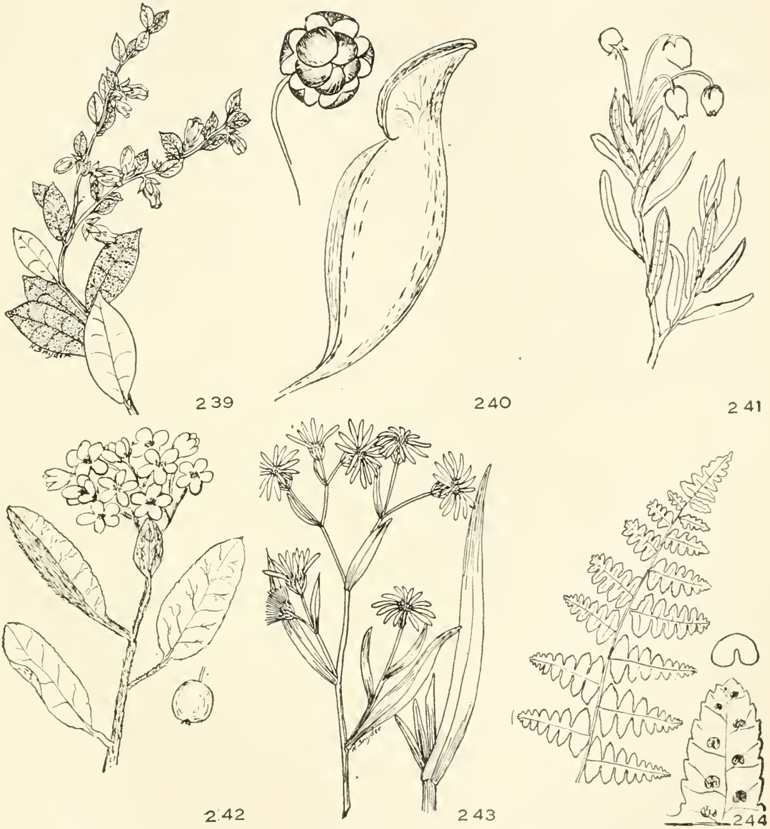
horsetail (Fig. 234) and on the drier parts of the sedge mat the swamp fern, *Aspidium Thelypteris* (Fig. 235).

Shoreward from the sedge zone is a zone in which the ground stratum is marked by an abundant growth of sphagnum moss (Fig. 236) above which is a shrub stratum with a striking group of xerophytes, the most conspicuous of which is the leatherleaf, *Chamaedaphne calyculata* (Fig. 239). The zone is usually called the cassandra zone. Sphagnum is a pale green moss whose spongy tissue holds with tenacity an immense bulk of water. It forms a soft carpet, often a foot deep. Below it the peaty soil lies to a depth of several feet usually saturated with water and very cold. The soil temperature will be in the neighborhood of 50° F. in midsummer, even on days when the air temperature is around 100° F.

Growing in the sphagnum one finds such orchids as *Arethusa* (Fig. 229), the ragged orchis (Fig. 237), fragrant ladies'-tresses (Fig. 238), together with cranberries, both large and small, cottony grass, and, most striking of all, the pitcher plant. This latter is another of the queer insectivorous plants found in this bog region. Its vase-like leaves which spring in clusters from the central root are 8 or 10 inches long and are lined with slippery hairs pointing down. The lip of the vase bears a ridge of succulent tissue on which numerous insects feed with avidity. In their eagerness they sometimes slip off into the pitcher which is partly filled with water. To crawl back against the sharp pointed hairs is not easy. So the bottom of the pitcher usually contains a more or less concentrated "insect soup" that is absorbed by the plant and serves as food (Fig. 240).

In the shrub zone besides the leatherleaf are found *Andromeda*, chokeberry, low birch, and other shrubs of similar character. *Andromeda* (Fig. 241) is a low evergreen shrub with narrow leaves that have their edges rolled back and the under sides of the young leaves covered with a white varnish. The urn-shaped corolla is pink, sometimes white. The flowers are in small clusters (umbels).

Chokeberry (Fig. 242) is a shrub a yard or so high. The leaves are shiny above, paler and covered with fine hairs below.



Figs. 239–244: Fig. 239.—Leatherleaf, *Chamaedaphne calyculata;* Fig. 240.—Pitcher plant, leaf and blossom, *Sarracenia purpurea;* Fig. 241.—Andromeda, *Andromeda Polifolia;* Fig. 242.—Chokeberry, *Pyrus arbutifolia;* Fig. 243.—Rush aster, *Aster junceus;* Fig. 244.—Crested shield fern, *Aspidium cristatum*, under side of one pinnula and outline of sorus.

The flowers are like apple blossoms and grow in clusters. The fruits, like small red apples, are .3 of an inch in diameter.

One familiar with the birches would recognize the swamp birch by its bark. Its leaves are egg-shaped, rounded, or even kidney-shaped. The young leaves as well as the branches are downy.

Leatherleaf shows well the characteristics of this group of xerophytes. Its leaves are thick and glossy with the wax in the epidermis; the under side of the leaf is scurfy—all devices to prevent the loss of water. One wonders at such xerophytic characters in shrubs growing in a swamp. But while water is abundant it seems to be difficult for the root hairs to absorb it. This is explained, in part at least, by the low soil temperature and the acidity of the soil. These conditions also prevent the decomposition of the plant débris accumulating from season to season, since they check the activity of the soil bacteria so necessary for this process. This débris accumulates, therefore, as peat instead of decomposing to help form humus as it would in most soils.

Next to the cassandra zone comes the tamarack zone (Fig. 226) with tamarack or larch trees as the most conspicuous plants. These are deciduous conifers with the needles in clusters of sixteen or more. Where these trees stand thickly, few plants grow under them, except the sphagnum which usually covers the ground. The soil is wet, peaty, and cold, for the sunlight does not penetrate the dense tamaracks readily. Soil temperature remains about 35° F. even in midsummer. In the more open parts of the tamarack bog, in addition to the herbaceous plants of the cassandra zone which invade it to some extent, there are found the rush aster (Fig. 243), swamp rose, *Rosa virginiana* with its stout hooked prickles, red-osier dogwood, poison sumac, (Fig. 107) and several ferns, the crested shield-fern (Fig. 244), royal (Fig. 203), and cinnamon ferns (Fig. 205).

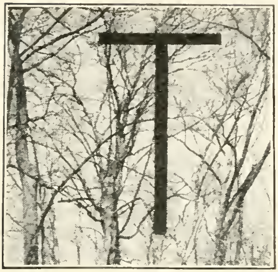
Shoreward from the tamarack zone there occurs a transition zone that varies according to the environment. One may pass from a typical black oak dune association to the tamarack bog society in a dozen steps, or the bog may gradually change to an interdunal swale of one of the preceding types. The transition may be from an oak-hickory forest in moraine country through a willow marginal zone occupied by the typical plants of the usual low, wet area.

One must expect to encounter many variations from the typical arrangement outlined above. The pond may have disappeared entirely as the floating sedges have overgrown it. The sedge zone may have disappeared and the sphagnum bog may occupy the whole depression, either with or without the tamarack border. The association may be in a still later stage in which the tamaracks only are present, the pond having filled, the floating sedge zone having been displaced by the sphagnum-cassandra association, and this in turn driven out by the advance of the tamaracks. This tamarack association may be gradually disappearing as plant débris accumulates, transforming the bog into a drier area with abundant humus in which the plants of the surrounding highland may establish themselves.

Most of the animals of the tamarack bog are not peculiar to it but are found in other marshes or swamps. In the water held by the leaves of the pitcher plant there breeds a species of mosquito that is subarctic. Certain orthoptera are the most characteristic animals of the sphagnum bog and its borders—the short-winged brown locust, *Stenobothrus curtipennis*, the striped locust, *Mecostethus lineatus*, the northern locust, *Melanoplus extremis*, the marsh ground cricket, *Nemobius palustris*, and the small brown cricket, *Anoxipha exigua*. The bog tiger beetle (p. 145) is also distinctive.

CHAPTER X

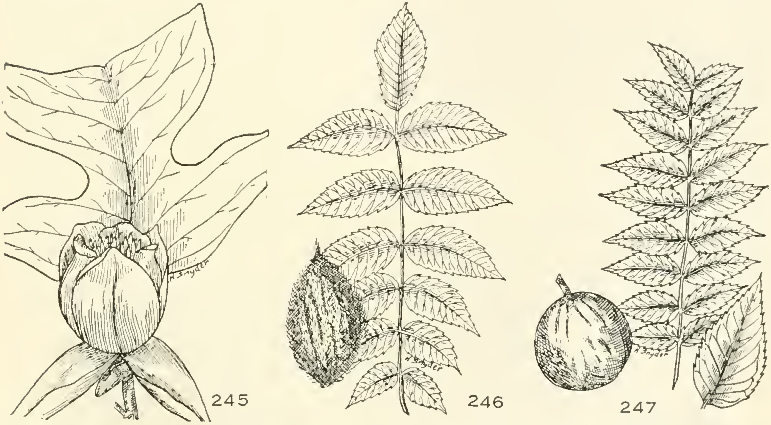
THE CLIMAX FOREST AND ITS PREDECESSOR, THE OAK-HICKORY TYPE



THE succession of stages traced in the preceding chapter lead on to the climax forest. On the dunes cottonwoods and their confrères are replaced by the pine association. This is in turn invaded and ultimately displaced by the black oak society. After many generations of accumulated forest débris, the soil becomes sufficiently rich in vegetable mold under such trees to support red oaks, then white oaks, and the mixed oak succession follows with its associated shrubs and herbs. Then hickories appear with the oak, and finally under most conditions maples and beeches displace all other trees. The interdunal pond and the filling lake, if they lead on to a forest at all, go through a similar succession and end in the same climax forest, except possibly in the case of the sphagnum bog.

Probably not one but many factors are involved in this succession. The increasing quantity of decomposing vegetable matter in the soil not only supplies more and more plant food but it also increases very greatly the power of the soil to retain moisture. The numerous penetrating rootlets of the dense forest growth, the burrows of earthworms and other animals not found in the earlier stages increase the porosity of the soil. Increasing shade prevents rapid evaporation, maintains a lower temperature by shutting out the sun's rays, reduces wind action, and lessens very greatly the light intensity. In the beech-maple forest the photographic exposure meter indicates a light intensity of only one-tenth to one-twentieth that of the surrounding open country. The plants and animals of the forest floor are therefore shade-loving and moisture-loving forms.

The maple-beech forest is the last in the succession because in the dense shade under these trees few seedlings other than beech and maple can survive; the young of the other trees demand more light. This is probably only one of several factors important in the elimination of other seedlings. As the pine forest grows old and dense, black oak seedlings appear, and these trees gradually overtop the pines, the latter dying in the struggle for existence. So in the black oak forest seedlings of red and white oak appear, and when mature they shut out the black oak, but the beech-maple forest has only beech and maple seedlings together with a few other trees that can stand the same conditions. There will be an occasional tulip tree (Fig. 245), black and white walnuts (Figs. 246, 247), black cherry (Fig. 248), hackberry (Fig. 249), with some elms (Fig. 250), and sycamore (Fig. 251) in the lower portions.



Figs. 245–247: Fig. 245.—Leaf and flower of tulip tree, *Lirodendron Tulipifera;* Fig. 246.—Leaf and nut of white walnut, *Juglans cinerea;* Fig. 247.—Leaf and nut of black walnut, *J. nigra.*

The tulip tree (Fig. 245) is recognized by its large leaf, shaped something like a maple leaf with the tip cut square off. The

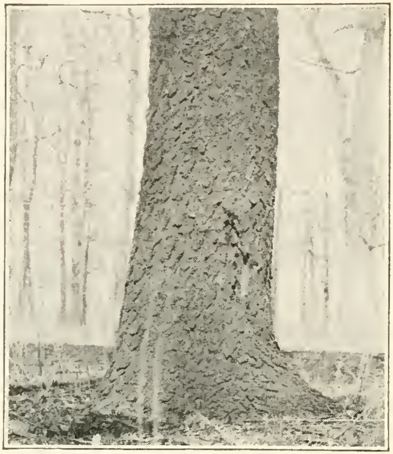


FIG. 248.—Trunk of the black cherry, *Prunus serotina.*

bark of the walnut has high ridges inclosing diamond-shaped areas. The pith of the twig is divided into numerous compartments by cross-partitions. The bark of the black cherry is broken into irregular polygonal areas by numerous cracks and so has something of the appearance of alligator-skin leather; the buds and twigs are bitter, tasting much like cherry pits. The bark of the hackberry has numerous high, corky, vertical ridges on it, while the bark of the sycamore scales off in flakes, showing light patches through the otherwise greenish brown bark.

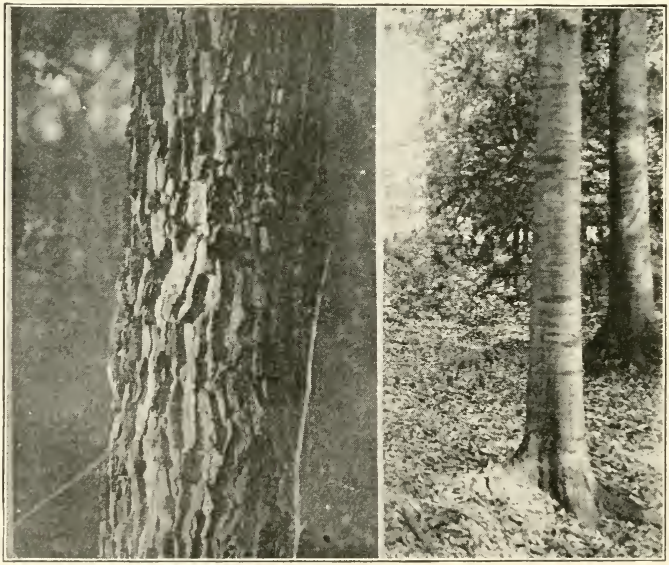


FIG. 249.—Hackberry trunk, *Celtis occidentalis*, and trunk of beech (at right)

The climax forest is distinctly stratified (Fig. 252). Beeches (Fig. 249) and hard maples (Fig. 253) rear their crowns in the intense sunlight. In such a superb example of the climax forest as is found in Warren's Woods near Three Oaks, Michigan, a forest preserved for all time to nature-lovers by the munificence of its owner, the late E. K. Warren, the trees rear unrivaled columns, 75 feet or more, without a branch. The Gothic aisles of this vast temple are ornamented with trees of less stature such as pawpaw, hop hornbeam, water beech, flowering dogwood, redbud, Juneberry, chokecherry (Fig. 116) whose tops form a second stratum. Then comes the tall shrub stratum with witch-hazel, spicebush, high bush cranberry, maple-leaved viburnum, nannyberry, wahoo, black currants, gooseberry, leatherwood, elderberry. Beneath these is a lower stratum of low shrubs, herbs, and ferns. Among the low shrubs are strawberry bush, pigeon berry (Fig. 265), shinleaf (Fig. 93), wintergreen (Fig. 94).

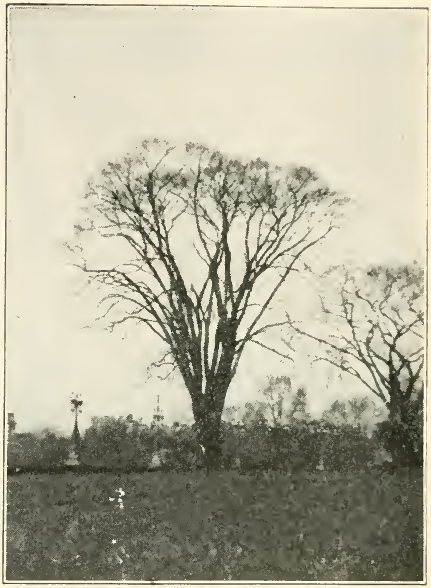


FIG. 250.—American elm, *Ulmus americana*

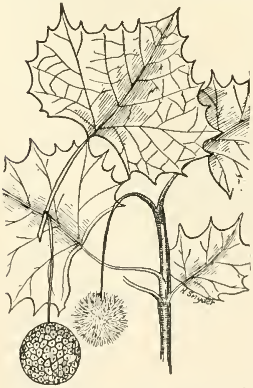


FIG. 251.—Leaf and fruit of sycamore, *Platanus occidentalis.*

The pawpaw (Fig. 256) has a trunk from 5 to 10 inches in thickness with dark brown smooth bark; the leaves are lance-shaped with the broad end toward the apex. The flower is quite conspicuous, an inch or two across, dull purple, with the parts in threes. The hop hornbeam and water beech have leaves much like elm leaves in general form. The former (Fig. 257) has fruits somewhat similar to hops. The bark of the tree is narrowly ridged and shreds off in narrow strips. The latter (Fig. 137) has a smooth trunk that is fluted like a Corinthian column. Witchhazel (Fig. 255) can usually be recognized by its fruits that remain on the shrub nearly the year around. The dogwood (Fig. 254) is a small tree conspicuous when in bloom, for the blossom cluster is subtended by four conspicuous white bracts. The redbud (Fig. 258) is also a low tree. Clusters of red pea-shaped blossoms come

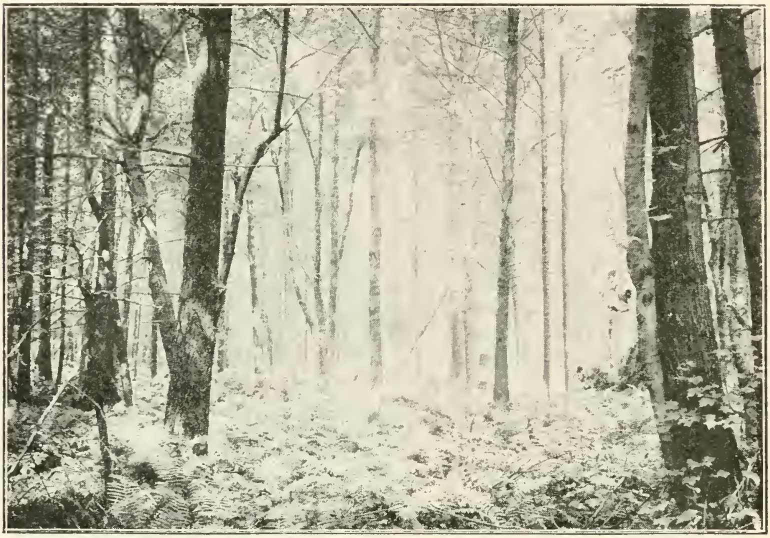


FIG. 252.—Climax beech-maple forest showing stratification

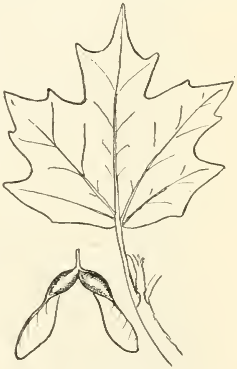


FIG. 253.—Hard maple leaf and fruit, *Acer saccharum*

in spring before the leaves. These blossoms appear on short branches that come out from the main trunk and main branches. Even when not in blossom the tree may be recognized by the presence of these short, stubby, flowering branches.

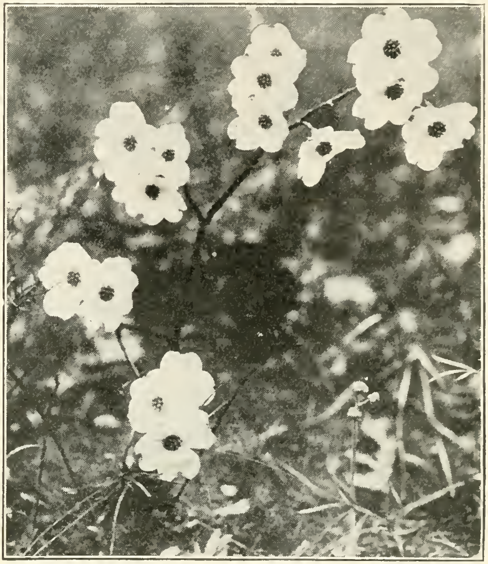


Fig. 254.—Flowering dogwood, leaf and blossom, *Cornus florida.*

The maple-leaved viburnum is similar to the high bush cranberry (Fig. 259) which is also a viburnum. It is a lower shrub, 3–5 feet high, with maple-like leaves that are downy below and fruits that are at first red, then purple. The nannyberry (Fig. 260), also a viburnum, has upper leaves that are taper-pointed and the leaf stems are winged. The fruit is black. Spicebush (Fig. 298) is recognized readily by the spicy odor of the crushed leaves and twigs. The high bush cranberry is a fairly tall shrub or low tree with oval, finely toothed leaves. The flower cluster of small white blossoms is large, and the red fruits conspicuous. The contained seed is flat. The wahoo (Fig. 261) is generally recognized by the four corky ridges that run longitudinally on

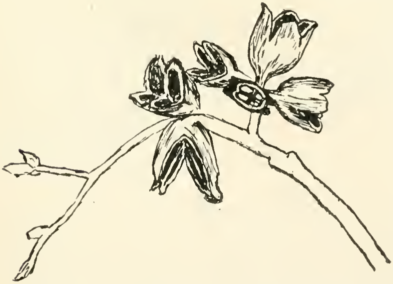
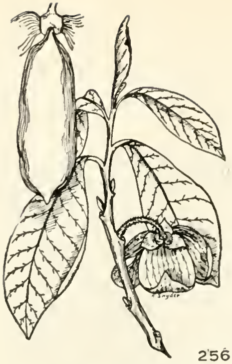


Fig. 255.—Twig of witch-hazel, *Hamamelis virginiana.*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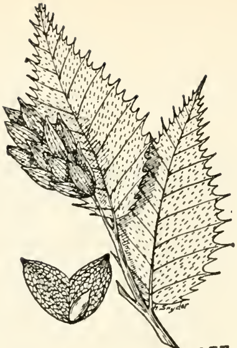
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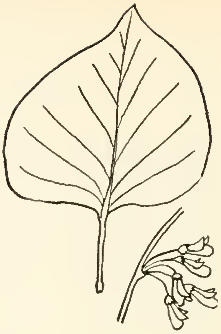
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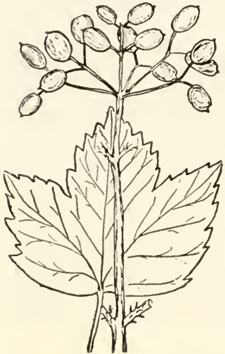
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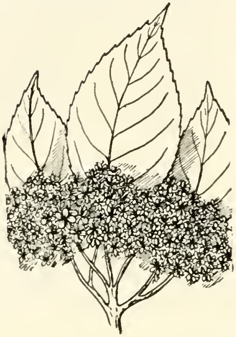
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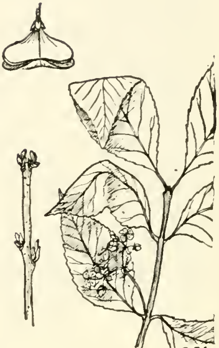
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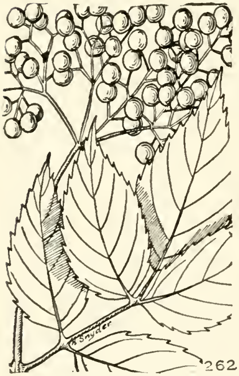
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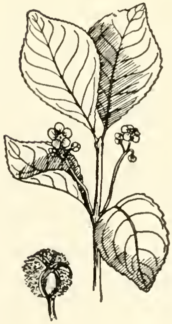
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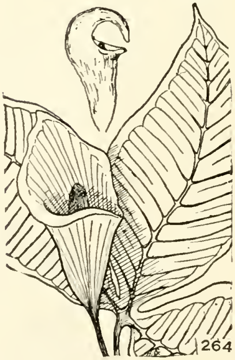
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FIGS. 256–264: Fig. 256.—Pawpaw, *Asimina triloba;* Fig. 257.—Hop hornbeam, *Ostrya virginiana;* Fig. 258.—Redbud, *Cercis canadensis;* Fig. 259.—High bush cranberry, *Viburnum opulus;* Fig. 260.—Nannyberry, *V. lentago;* Fig. 261.—Wahoo or burning bush, *Evonymus atropurpureus;* Fig. 262.—Elderberry, *Sambucus canadensis;* Fig. 263.—Strawberry bush, *Evonymus americana;* Fig. 264.—Jack-in-the-pulpit, *Arisaema triphyllum;* the larger figure shows the top of the "pulpit" thrown back.

each twig, giving the twig a square cross-section. Leatherwood is low, not over 7 feet high, with very soft, white wood and very tough, fibrous bark. The branchlets are jointed, and the leaves are very short-petioled. Elderberry (Fig. 262) is readily recognized by the very large amount of pith in the stems. The wood layer is relatively thin. Strawberry bush (Fig. 263) is a low shrub with more or less of a creeping habit. The leaves are almost without stalks, lance-shaped, and finely toothed.

On the ground of such a forest there are a large number of plants (Fig. 55) that spring up quickly in the spring before the trees are in leaf, blossom, and mature their fruit before they are so densely shaded as to preclude their intense activity. The spring beauty, spring cress, toothwort, hepatica (Fig. 139), bloodroot, red and white trillium, dog-tooth violet, jack-in-the-pulpit (Fig. 264), green dragon (Fig. 266), Dutchman's breeches, wild ginger, all belong to this group. This vernal flora consists of plants in whose underground stems or succulent roots there is stored abundant food for this burst of speed in the accomplishment of their life-cycle. In many cases, too, their leaves and flower buds are warmly clothed in hair, and not a few have leaves that cuddle close to the warm earth in dense clusters.

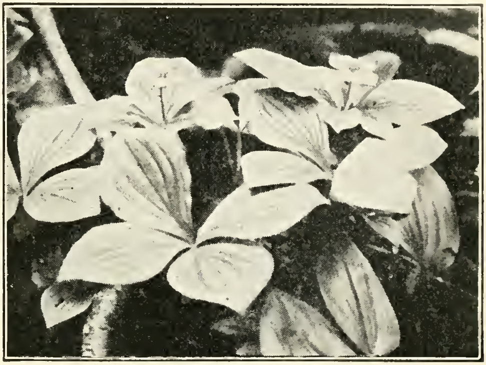
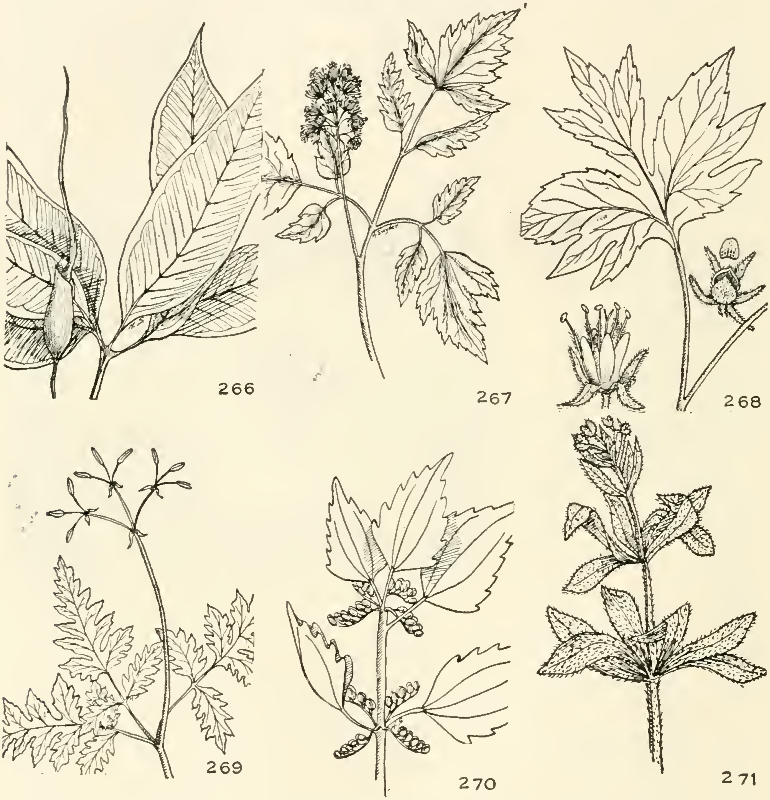


FIG. 265.—Pigeon berry or dwarf cornel, *Cornus canadensis*.

Later the ground is pre-empted by plants that are better able to endure the shade and that take more time to blossom and mature their fruit. Such are the long-spur (Fig. 143) and Canadian violets (Fig. 142), wood violet, the latter with a palmately five- to nine-lobed hairy leaf, wood phlox, the columbine

(Fig. 122), red and white baneberry, Solomon's seal, waterleaf, sweet cicely, clearweed (*Pilea pumila*), bedstraw, ginseng, touch-me-not. Certain kinds of ferns are very characteristic of such woods, and the many sorts that grow are here noted for their luxuriance. The beech fern (Fig. 274), maidenhair (Fig. 275), wood spleenwort (Fig. 276), pale wood fern (Fig. 277), Christmas fern (Fig. 278), lady fern (Fig. 279), margined fern (Fig. 280), florists' fern (Fig. 281), and ostrich fern (Fig. 282) are among the



Figs. 266–271: Fig. 266.—Green dragon, *Arisaema dracontium;* Fig. 267.—Baneberry, *Actaea alba;* Fig. 268.—Waterleaf, *Hydrophyllum virginianum;* Fig. 269.—Sweet cicely, *Osmorhiza Claytoni;* Fig. 270.—Clearweed, *Pilea pumila* Fig. 271.—Bedstraw, *Galium aparine.*

sorts to be found, some abundantly, others only in favorite spots. In ravines and lower areas the cinnamon fern, Clayton's fern, and sensitive fern are to be noted, while the brake (Fig. 283) is common on borders and open spots. Many mosses grow on the decaying logs and on the moist ground; lichens are plentiful and fungi particularly abundant.

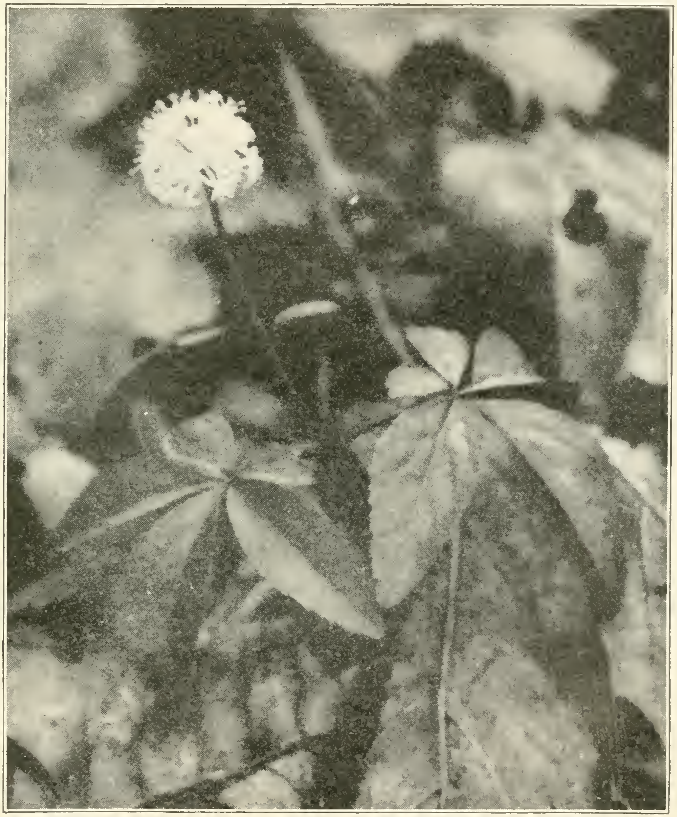


FIG. 272.—Ginseng, *Panax trifolium*

Baneberries (Fig. 267), both white and red, are low shrubs with a leaf having a three-parted stalk, each division bearing three to five leaflets. In water leaf (Fig. 268) the green leaves are mottled with pale areas looking as if the darker color had been washed out by sprinkling water on the leaf. The leaves are quite large, deeply lobed, and hairy. Sweet cicely (Fig. 269) gives the odor or taste of licorice when the foliage is crushed. Clearweed (Fig. 270) has a semi-transparent stem. The leaves are egg shaped and bear large coarse teeth. The flower clusters are in the axils of the leaves. The plant looks like a nettle, but does not have stinging hairs. Bedstraw (Fig. 271) is a low trailing herb whose foliage is harsh. The stems are covered with points that make them very rough. Ginseng (Fig. 272) when in blossom is readily recognized by the small ball of white flowers. Touch-me-not (Fig. 273) only occurs in the moist places. The stem is translucent; the flowers are yellow, mottled with dark spots. The seed pod, when ripe, explodes on touch, scattering seeds to some distance.

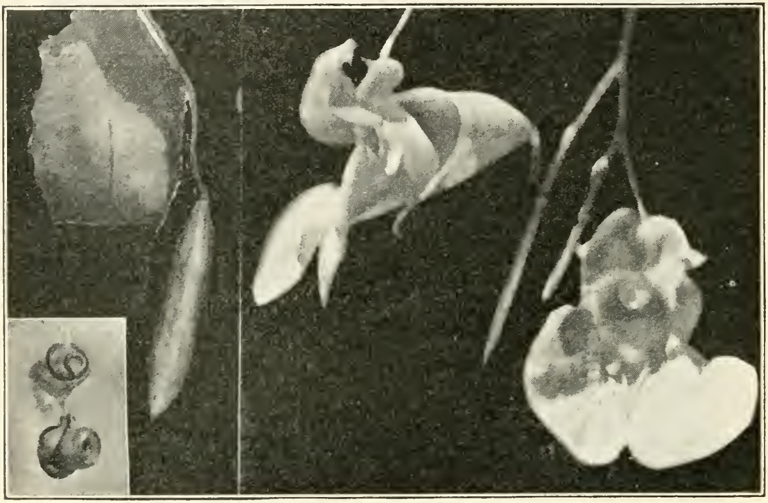
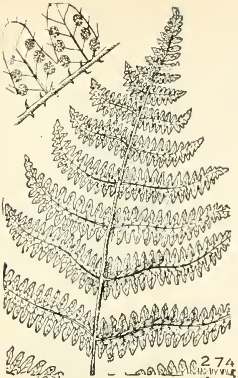


FIG. 273.—Touch-me-not or wild balsam, *Impatiens pallida.* Blossoms at right, pod at left; inset, pods after discharge of seeds.

Animal life is as abundant and varied as the plant life. Earthworms are abundant in the soil. Here, too, are some insect nymphs like that of the cicada. Some rodents are present as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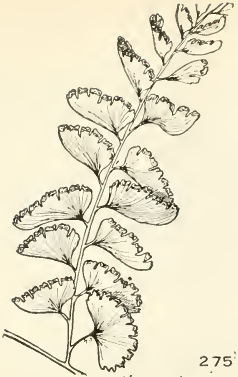
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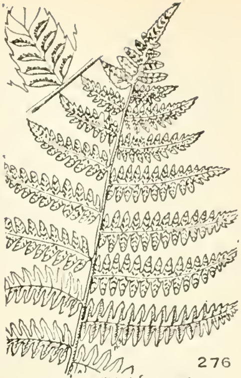
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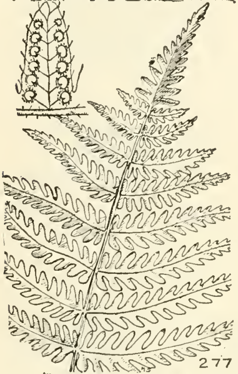
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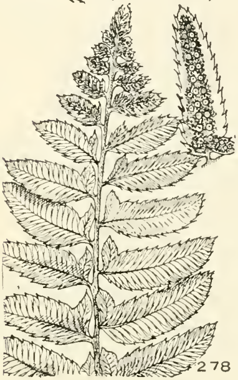
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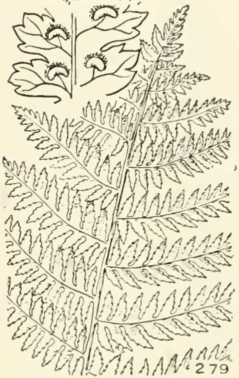
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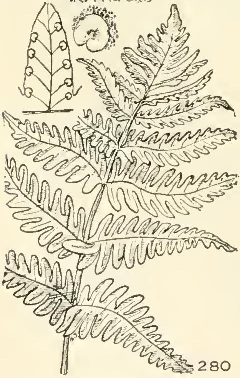
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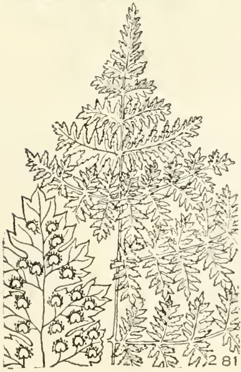
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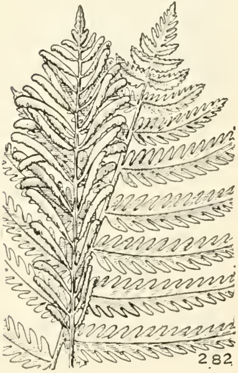
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FIGS. 274–282: Fig. 274.—Beech fern, *Phegopteris polypodioides;* Fig. 275.—Maiden-hair fern, *Adiantum pedatum*, portion of frond; Fig. 276.—Wood spleenwort, *Asplenium acrostichoides;* Fig. 277.—Pale wood fern, *Aspidium novaboracense;* Fig. 278.—Christmas fern, *Polystichium acrostichoides;* Fig. 279.—Lady fern, *Asplenium Filix-femina;* Fig. 280.—Margined fern, *Aspidium marginale;* Fig. 281—Florists' fern, *A. spinulosum;* Fig. 282.—Ostrich fern, *Onoclea struthiopteris.*

characteristic inhabitants, such as the common mole (Fig. 286); the common or long-tailed shrew, similar to the short-tailed (Fig. 425), but the former is only 4 inches long, the tail making 1.5 inches of that length; the latter is 5 inches long and the tail is only 1 inch or less; and the white-footed deer mouse (Fig. 287). Under and in the old logs in various stages of decay are found a host of snails. Indeed, this moist forest is the favorite haunt of the land snails and slugs, *Polygyra albolabris*, *fraudulenta*, *hirsuta*, *inflecta*, *monodon*, *oppressa*, *palliata*, are abundant as are also *Pyramidula alternata*, *perspectiva*, and *solitaria*, *Omphalina fuliginosa* and *friabilis*, *Zonitoides arboreus*. *Circinaria concava* is common, a carnivorous form that feeds on other land snails (Figs. 284, 285). In moist weather all these kinds may be found traveling over the leaves upon the ground, old logs, shrubs, and tree trunks. In drier weather they are in hiding under logs and stumps. The *Polygyras* are all land snails distinguished by the fact that the edge of the opening of the shell is reflected in a broad lip. *P. fraudulenta* and *P. inflecta* have two projections called "teeth" on the lip of the opening, one on the body wall (parietal tooth). The former has an open umbilicus at the base of the spire, the latter has none. *P. monodon*, *P. hirsuta*, and *P. fraterna* are small, one-half inch or less in diameter. The lip is notched in *hirsuta*, and the shell is covered with short dense hair. *P. fraterna* is similarly hairy, but the lip is not notched.

FIG. 283.—Bracken fern, *Pteris aquilina*

Its shell is narrowly umbilicate. *P. monodon* is not hairy, the lip is not notched, and it is widely umbilicate. The following are much

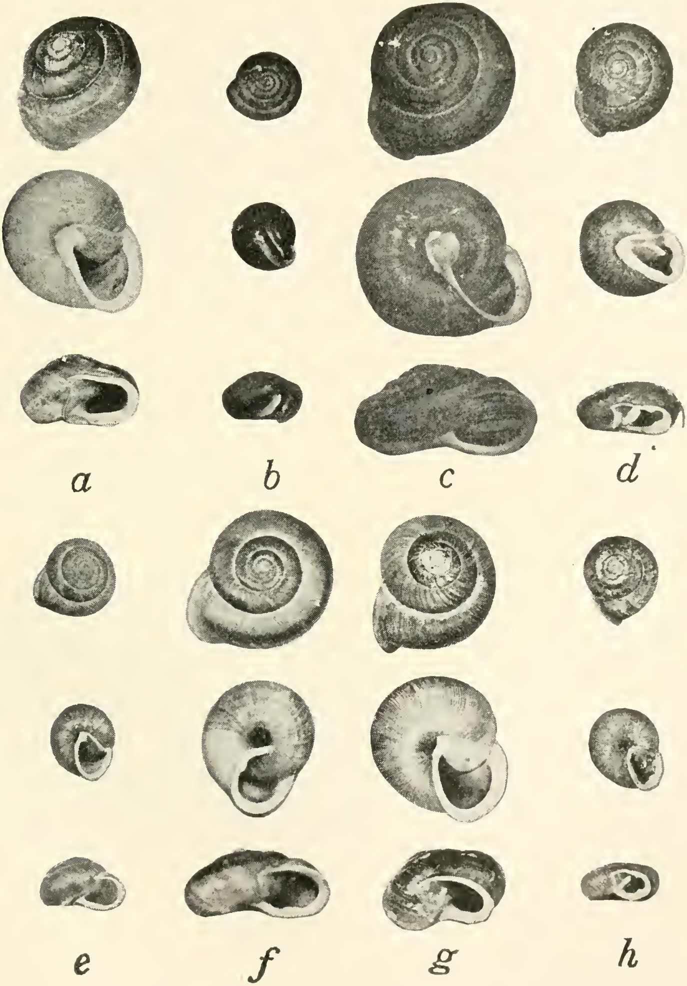


FIG. 284.—Various species of *Polygyra*, common land snails, life size: *a*, *Polygyra albolabris*, the white-lipped snail (note covered umbilicus); *b*, *P. hirsuta*, the hairy snail (note notch in lip); *c*, *P. multilineata*, the many-banded snail; *d*, *P. palliata;* *e*, *P. pennsylvanica;* *f*, *P. profunda* (note wide open umbilicus); *g*, *P. thyroides;* *h*, *P. tridentata*, the three-toothed snail.

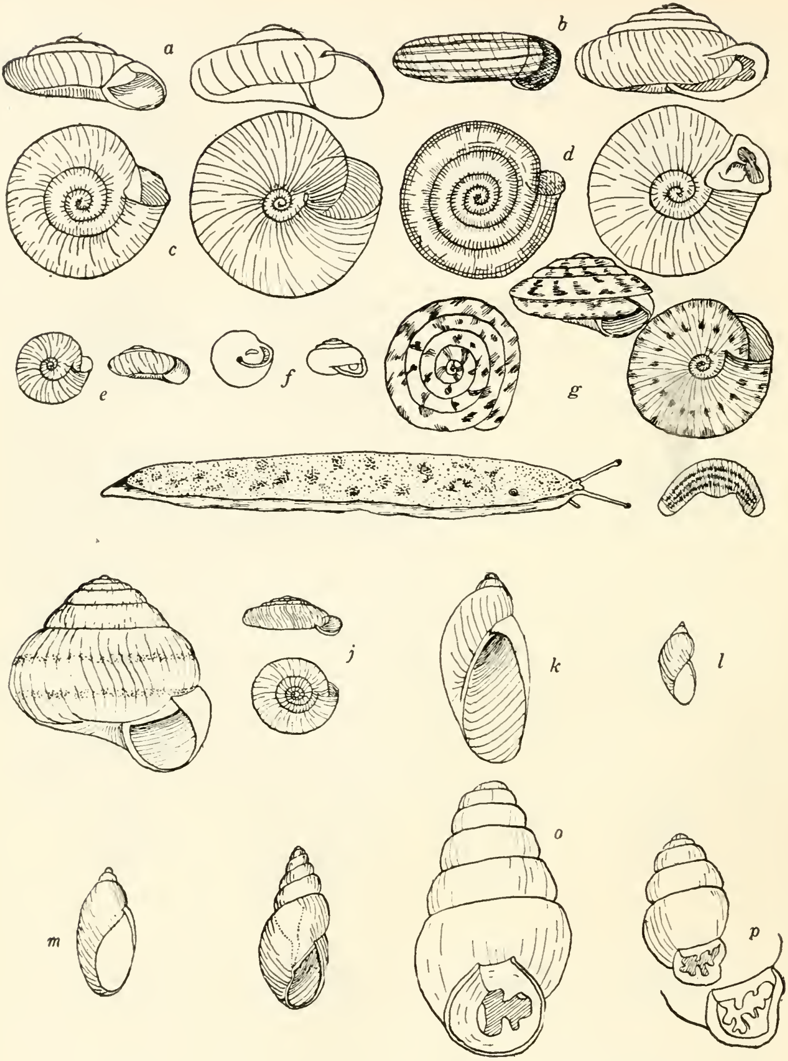


FIG. 285.—Land snails: *a*, *Circinaria concava;* *b*, *Helicodiscus parallelus;* *c*, *Omphalina fuliginosa;* *d*, *Polygyra tridentata;* *e*, *Zonitoides arboreus;* *f*, *Polygyra monodon;* *g*, *Pyramidula alternata;* *h*, *Philomycus carolinensis* (a slug); *i*, *Pyramidula solitaria;* *j*, *P. perspectiva;* *k*, *Succinea avara;* *l*, *S. ovalis;* *m*, *S. retusa;* *n*, *Cochlicopa lubrica;* *o*, *Bifidaria armifera;* *p*, *Vertigo ovata;* the last three much enlarged.

larger shells. *P. multilineata* and *P. profunda* are marked with revolving brown bands and are the only ones so marked: the former has no umbilicus; the latter, a very wide one. *P. albolabris* has the umbilicus completely covered, *P. pennsylvanica*, nearly covered, *P. thyroides* about half-covered. The latter is distinctly striate with fine ridges. *P. clausa* is similar but unstriate, and the shell is high as compared with that of *P. thyroides*.

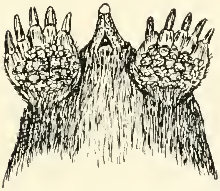


FIG. 286

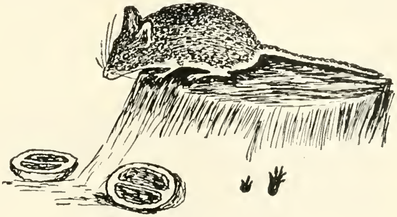


FIG. 287

FIGS. 286, 287: Fig. 286.—Under side of head end of common mole, *Scalopus aquaticus;* Fig. 287.—White-footed deer mouse, *Peromyscus leucopus*, and imprint of fore and hind foot, reduced one-half.

The *Pyramidulas* do not have the reflected lip. Their shells are quite flat and coarsely striate. *P. perspectiva* and *striatella* are small. The former, .5 inch in diameter, reddish in color, has six and one-half whorls. The latter, .25 inch in diameter, is brown in color and has only four whorls. *P. solitaria* has three spiral brown bands, while *P. alternata* is marked with alternate patches of dark and light. The *Omphalinas* have paper-thin polished shells. *O. fuliginosa* is mahogany brown with a pearly aperture. *O. friabilis* is similar, but the shell is still thinner. *Zonitoides arboreus* is small, only .12 inch in diameter. The shell

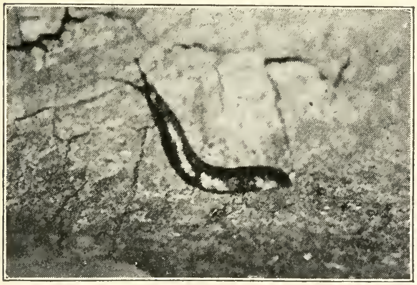


FIG. 288.—The common slug, *Agriolimax campestris.*

is amber if empty, dark brown when the animal is in it. *Circinaria concava* is .5 inch or more in diameter, green horn-color outside and red-brown within the aperture.

The great slug, *Philomycus carolinensis* (Fig. 285), and the smaller slugs, *Agriolimax campestris* (Fig. 288) and *Pallifera dorsalis*, are found in similar situations. Not infrequently under strips of bark one finds clusters of the eggs of slugs or snails like heaps of small pearls. *Philomycus* is yellow white, spotted with brown or black. The other two are ashy in color. *Pallifera* has a dark line down the back and is less than an inch long. *Agriolimax* is larger with no line down the back. Under the bark of logs in midstages of decay one finds also several centipedes and millipedes. The big round *Spirobolus marginatus* (Fig. 289)—.5 inch in diameter and 5 or 6 inches long when full grown—is fairly common. Another, *Fontaria corrugate* (Fig. 290), is flattened somewhat and is brown in color with yellow margins. *Lysiopetalum lactarium*, a centipede, discharges a milky fluid when handled, while *Geophilus rubens* (Fig. 291) is a large reddish fellow. Sow bugs and roaches are abundant here, too. In logs that are in earlier stages of decay one finds numerous boring beetles. The click beetles and their larvae, the wire worms,

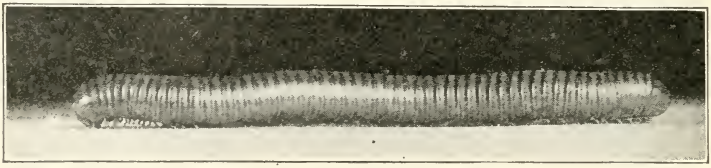


FIG. 289.—The large millipede, *Spirobolus marginatus*

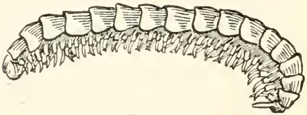


FIG. 290

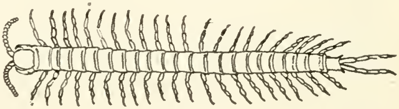


FIG. 291

FIG. 290, 291: Fig. 290.—Yellow-margined centipede, *Fontaria corrugate;* Fig. 291.—The red centipede, *Geophilus rubens.*

including the big eyed elater (Fig. 292), are common under the bark, as are some ground beetles in hiding here. The green-legged locust and Blatchley's locust (Fig. 293) are characteristic. In the wood, in galleries which they excavate, are the larvae of wood borers; the flatheads, larvae of metallic wood borers, and the fleshy grubs of the horned *Passalus* (Fig. 294). Carpenter ants and carpenter bees, the latter small but brilliantly colored in metallic blues and greens, are to be found in the same situation. Several species of beetles (Fig. 295) are found in the fungi on the forest floor and on old logs. Two amphibians are characteristic here, the red-backed salamander found hiding in moist recesses under old logs, and the wood frog, *Rana sylvatica* (Fig. 296). The latter is so common, hopping on the forest floor, and so characteristic of the climax forest that Shelford calls this beech-maple society the wood frog association. Tree frogs, *Hyla versicolor* and *H. pickeringii*, are found here but are also abundant in earlier forest stages (Figs. 173, 174).

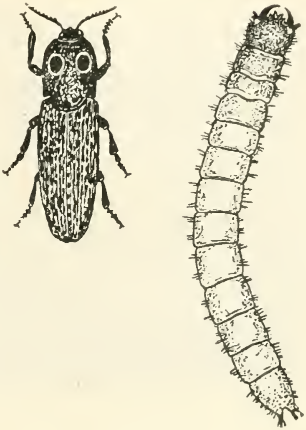


Fig. 292.—The eyed elater, *Alaus oculatus*, and its larva.

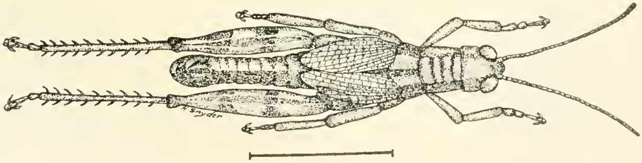


Fig. 293.—Blatchley's locust, *Melanoplus blatchleyi*

In the shrub stratum are some characteristic insect larvae and some spiders. The larva of *Papilio ajax* is found on the pawpaw, and the butterfly wings its tantalizing flight through the forest and about its margin (Fig. 297). The green-clouded swallowtail, *Papilio troilus* (Fig. 298), rears its young on the spicebush. *Epeira gigas, Neocosoma arabesca* (Figs. 304, 305) are characteristic spiders hanging their webs on the taller shrubs, though they are even more abundant in the oak-hickory association.

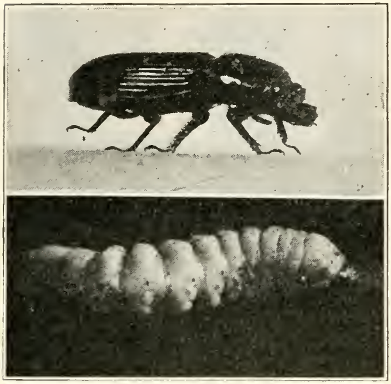


FIG. 294.—The horned Passalus and its larva, *Passalus cornutus.*

This forest is the home of many birds. The ovenbird builds its overarched nest on the ground. The wood pewee calls plaintively from the quiet deeps of the woods. The evening song of the wood thrush lends charm to the quiet hour. Both these and the red-eyed vireo, the scarlet tanager, and the great crested flycatcher nest in the shrubs and low trees. During migration the tree tops are alive with warblers; the black and white creeping and the yellow warblers remain to nest. The red-shouldered hawk, together with some other hawks, nest early in the taller trees. At dusk the call of the little screech owl, a wavering minor whistle, and the hoot of the great horned owl are heard. These nest in February in the hollows of the trees.

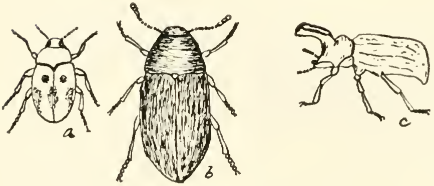


FIG. 295

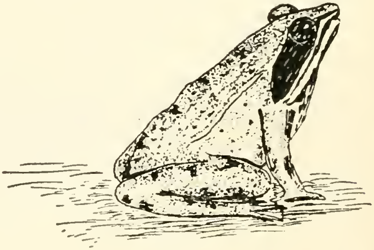


FIG. 296

FIGS. 295, 296: Fig. 295.—Fungus beetles: *a, Diaperis maculata; b, Pisenus humeralis; c, Boletotherus bifurcus;* Fig. 296.—The wood frog, *Rana sylvatica.*

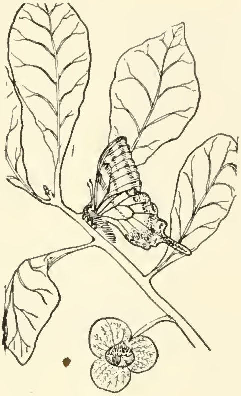


Fig. 297

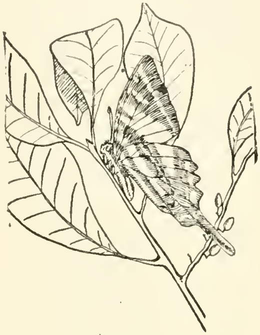


Fig. 298

Figs. 297, 298: Fig. 297.—Pawpaw swallowtail, *Papilio ajax*, on pawpaw; Fig. 298.—Spicebush swallowtail, *P. troilus*, on spicebush.

The oak-hickory forest, with scattered individuals of black cherry, walnut, and linden, is the prevalent type on the moraines about Chicago. It also is stratified as is the beech-maple forest, though the undergrowth is as a rule not as tall nor as abundant. Hazel, dogwood, and the wild rose are among the common shrubs. The spring herbaceous plants are similar to those of the beech-maple forest. Goldenrods, asters, and sunflowers are abundant in the fall. Ferns are at times abundant, but only a few of the ferns found in the beech-maple forest are present in the oak-hickory forest. The common ones are cinnamon fern, the interrupted fern, the sensitive fern in the moist areas, and the brake in open spots.

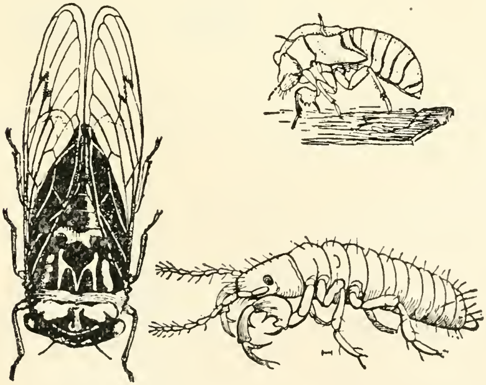


Fig. 299.—Cicada, *Cicada linnei*, and nymph of a cicada, the one below much enlarged. From Lugger.

There are characteristic animals in the soil, on the ground, and in the litter of decaying leaves close to the ground. There are specific societies on the fungi and in decaying logs, a society peculiar to the forest undergrowth of shrubs and herbaceous plants and a distinct community of the forest crown.

The cicada or periodical locust (Fig. 299) sings its strident drone in the tree tops, though most of its life, as a nymph, is spent in the soil stratum of the forest. The katydid, *Cyrtophillus perspicillatus*, lives its entire life from egg to adult in the tree tops. The tree cricket (Fig. 300) is common, as also the walking-stick. There are a number of butterfles and moths whose larvae feed upon the foliage. Among these are the tiger, swallowtail (cherry), and the giant swallowtail (hop tree), the walnut sphinx, the lunar moth (hickory, walnut), the royal moth (walnut), imperial moth (many trees), Polyphemus (many), Promethea (cherry), yellow-gray underwing (hickory), the widow (hickory), Cecropia (many).

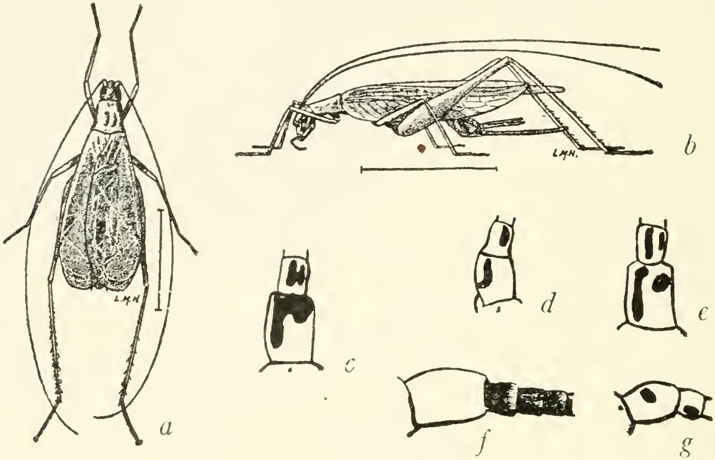


FIG. 300.—Tree crickets of several species: *a*, male, *b*, female of *Oecanthus fasciatus;* *c*, Basal joint of antennae of *O. fasciatus;* *d*, *O. angustipennis;* *e*, *O. quadripunctatus;* *f*, *O. latipennes;* *g*, *O. nivens.*

Many beetles are peculiar to the forest crown such as the oak twig pruner (Fig. 301), the hickory girdler, *Oncideres cingulatus*, whose larvae develop in twigs that have fallen to the ground after being girdled more or less completely by the adults up in the trees. Several species of the June beetles are found feeding on the leaves, as are many kinds of leaf beetles such as *Tymnes tricolor*, *T. matasternalis*, *Chalepus nervosa*, *C. rubra* (Fig. 302), *Xanthonia 10-notata*. These are small beetles .25 inch or less in length. Most of the leaf-eating beetles are small. The elm-leaf beetle, *Galetucella luteola*, is one of the most familiar of the leaf beetles attacking tree foliage. Acorns and hickory nuts afford homes and food for the larvae of several species of nut weevils belonging to the genus *Balaninus* (Fig. 303) and later to some moth larvae. These tall tree tops afford good nesting sites to the red-headed woodpecker, the flicker, and the larger owls. The flying squirrel, which is largely nocturnal, spends its life in the trees.

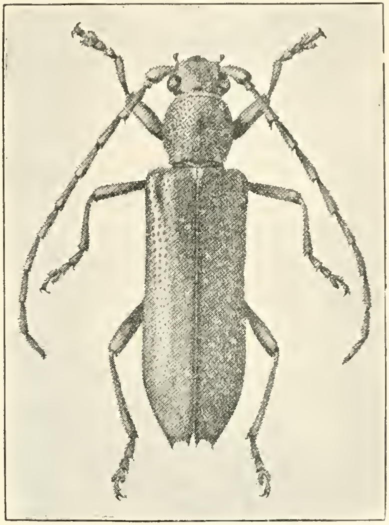


FIG. 301.—Twig pruner of oak, *Elaphidion villosum*. ×3.

In the undergrowth community the spiders, *Epeira gigas* (Fig. 304) and *Neocosoma arabesca* (Fig. 305), are characteristic; their webs are hung on the taller shrubs. The jumping spider, *Phidippus audax* (Fig. 306), is prevalent in shrubs, on tree trunks,

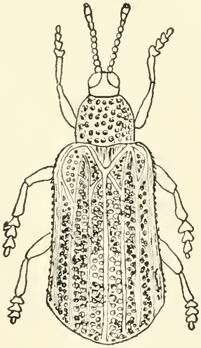


FIG. 302

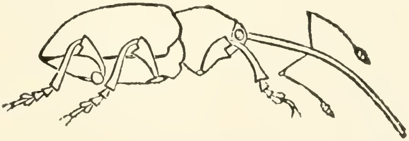


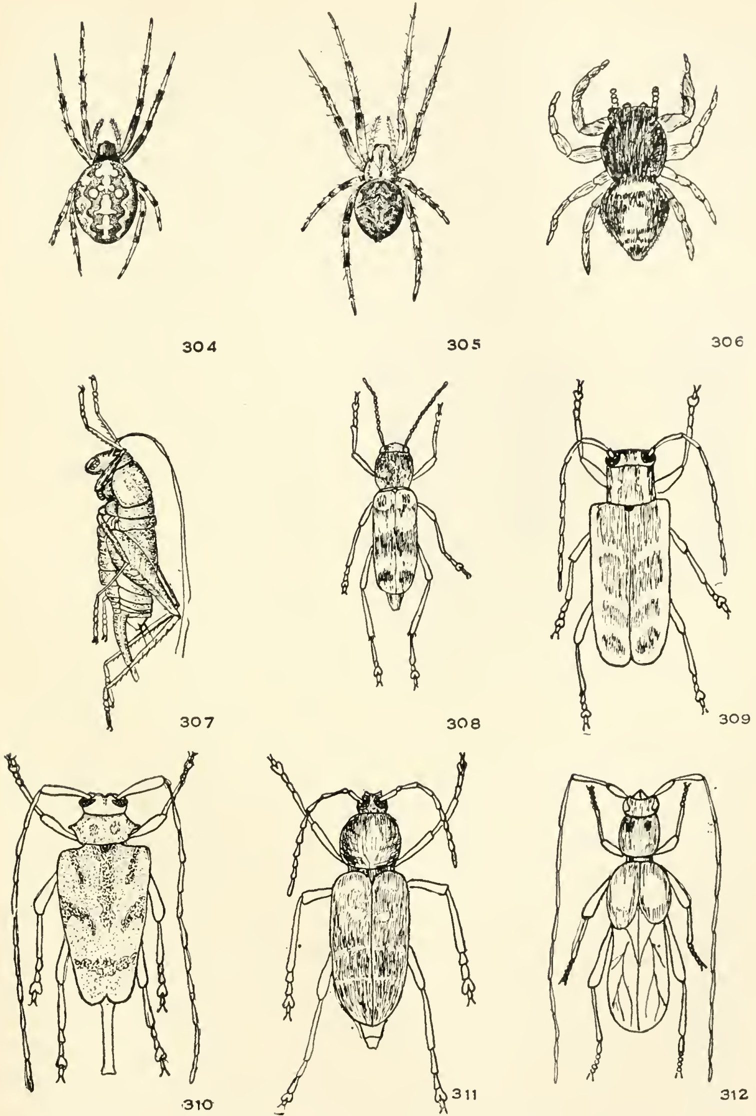
FIG. 303

FIGS. 302, 303: Fig. 302.—A leaf beetle, *Chalepus rubra*. After Blatchley; Fig. 303.—A nut borer, genus *Balaninus*. Both ×6.

and fallen logs. Harvest spiders or daddy longlegs are abundant. Among butterflies the wood nymph and wood satyr are conspicuous by their numbers. The forked-tail and round-winged katydids are prevalent (Fig. 322).

The ground stratum is thickly populated. The most conspicuous denizen is perhaps the green tiger beetle, and Shelford names the oak-hickory association, on its animal side, the green tiger-beetle association. This brilliant tiger is only one of several predatory ground beetles common on the forest floor. They are about the same as found in the wood frog association. The commonest inhabitants of the leaf litter are the myriopods, of which various species of "thousand legs" (millipedes) of the genus *Polydesmus* and "hundred legs" (centipedes) of the genus *Lithobius* are most prevalent. Thirty or forty to the square yard may often be found when the leaf litter is carefully looked over. They are an important factor in the transformation of the dead leaves to leaf mold. Occasionally one finds the other myriopods common in the wood frog association in the litter, but they are more often under loose bark on old logs; they are not as common as in the beech-maple forest. The same thing may be said of the slugs and snails. The camel cricket (Fig. 307) and the short-winged locust are fairly abundant. The nymphs of cicadas are common, discovered on their way from the soil stratum, where they live, to the trees where they emerge as adults. In dry seasons the nymphs protect themselves from excessive evaporation by building a closed clay chimney up through the leaf mold, rising sometimes an inch or two above the surface. In this they lie until they are ready to accomplish their transformation on the nearby tree trunk.

There is a constantly changing association in the trunks of the trees, beginning with the standing trunk still in its prime, continuing through the dead standing timber, the fallen log, in its various stages of decay. The rustic borer (Fig. 308) works in the wood of the hickory, oak, and beech trunk even when the tree is robust. The elm borer (Fig. 309) begins work on



FIGS. 304–312: Fig. 304.—Female of the spider, *Epeira gigas;* Fig. 305.—Female of the spider, *Neocosoma arabesca;* Fig. 306.—The jumping spider, *Phidippus audax,* ×3; Fig. 307.—Female of camel cricket, *Ceuthophilus maculatus;* Fig. 308.—Rustic borer, *Xylotrechus colonus;* Fig. 309.—Elm borer, *Saperda tridentata,* ×2; Fig. 310.—*Graphisurus fasciatus,* ×3; Fig. 311.—*Calloides nobilis,* slightly enlarged; Fig. 312.—*Molorchus bimaculatus.*

the trunk if the tree is at all weakened. An allied species, *Saperda lateralis*, is also found on the hickory, and *S. vestile* is very destructive. The larva of the goat moth also attacks lusty trees and bores into their heartwood. It is good sized—some two or more inches long when full grown. Such forms open the trees' defenses to a legion of other insect pests that are seldom slow to follow up the advantage and that bore into the wood or undermine the bark. Such are the flathead apple-tree borer (Fig. 313). The adult beetle of the last-named species has been known to emerge from wood made into furniture several years after the manufacture of the article, the pupa having lived during a long period of imprisonment, so it is claimed.

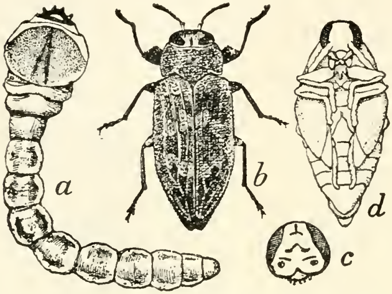


Fig. 313.—Flathead apple-tree borer, *Chrysobothris femorata; a*, larva; *b*, adult; *c*, face of larva; *d*, pupa. After Chittenden.

When the tree has succumbed and stands as a dead or nearly dead tree, the oak is attacked, in addition to the foregoing, by such forms as *Graphisurus fasciatus* (Fig. 310), *Calloides nobilis* (Fig. 311), while the hickory supports even a larger beetle population, common among which are *Liophus alpha*, *Stenosphenius notatus*, *Molorchus bimaculatus* (Fig. 312). The decay of the log goes on through many years, and the population changes as decomposition progresses. The trunk may still stand or it may be lying on the ground when the bark loosens and the underlying sapwood begins to rot. Under such conditions one finds a curious assemblage of animals representative of many phyla. The slugs already mentioned in the beech log are present, though not as commonly as in the more mesophytic wood frog association. They are usually found near the base of the standing stump. Snails are represented by *Polygyra albolabris*, *P. thyroides*, and other species of *Polygyra* already listed in the beech-maple forest.

Pyramidula alternata is common as are also *P. perspectiva*, *Omphalina fuliginosa*, *Zonitoides arboreus*, and *Circinaria concava*. Millipedes and centipedes are almost invariably present. The carpenter ant is beginning to work, the female being found early in the spring, starting the colonies in small hollows excavated in the decaying wood. The paper wasp frequently winters under such loose bark. Certain spiders, such as the wolf spider and the grass spider, winter in such localities and deposit their egg sacks here.

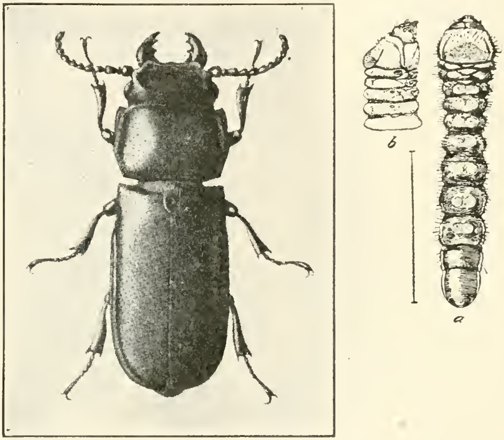


FIG. 314.—Heartwood borer, *Parandra brunea*, and *a*, its larva; *b*, side view of head end (*Bulletin United States Department of Entomology*).

When the bark becomes quite loose on standing timber, the brown bat hangs up under its protection by day. But the predatory and wood-boring beetles make up the bulk of the population. The heartwood borer, *Parandra brunea* (Fig. 314), is frequently present, working where decay is just beginning. This is a shiny, chestnut brown beetle about .75 of an inch long and a third as wide. The nearly cylindrical larva is 1 inch long, and is recognized by the sharply sloping thorax and the small head. *Eupsalis minuta* is quite common under bark of oaks, even in early stages of decay (Fig. 315). The horned passalus, a good-sized black beetle with a horn on the thorax, may be present, though it is more common in the fallen logs when decay has progressed somewhat more. Its very large white four-legged larva is not likely to be mistaken for anything else (Fig. 294). Click beetles are almost always present. *Xylopinus saperdioides*, *Nytrobates* *pennsylvanica* (Fig. 316), *Tenebrio tenebrioides* (Fig. 317), *Uloma impressa*, *Meracintha contracta* are all beetles more than half an inch long that are common in such situations. All belong to the family of darkling beetles, and the list might be much extended.

Then as decay becomes more complete other forms largely replace those listed above, although some of these, as for instance *Passalus cornutus*, remain even in well-decayed wood. The rotten-log caterpillar, *Scolesocampa*, also is found from early to late stages.

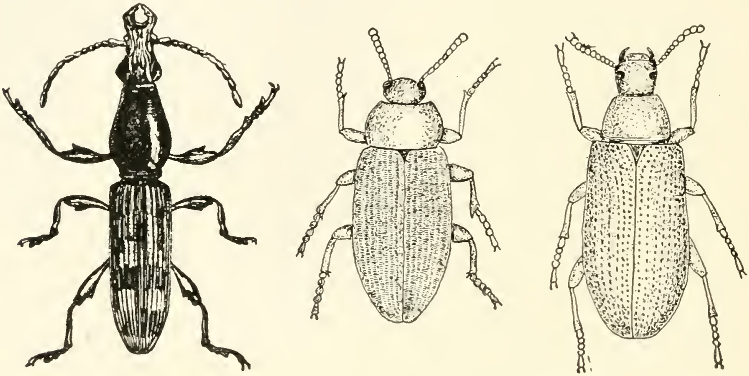


Fig. 315 Fig. 316 Fig. 317

Figs. 315–317: Fig. 315—Oak borer, *Eupsalis minuta*. After Felt; Fig. 316.—Beetle, *Nyctobates pennsylvanica;* Fig. 317.—Beetle, *Tenebrio tenebrioides*. All ×2.

The transition from the upland forest to the surrounding prairie is accomplished through a characteristic forest margin association. For the oak-hickory forest that is so commonly the climax on the morainal hills in the immediate vicinity of Chicago this consists of the wild crab often draped with the wild grape, the trembling asp, the hawthorns, an occasional wild plum, the smooth and staghorn sumacs, hazelnut, nannyberry, and other viburnums, and not uncommonly some of the dogwoods. The spring and summer herbaceous plants are not materially different from those of the adjacent forest. The May apple may make a goodly showing, the Canada and spear thistles and ground-cherry may be particularly abundant, or the milkweed toss its balls of blossoms in profusion, while in the autumn goldenrods, wild sunflower, and asters seem to run riot here.

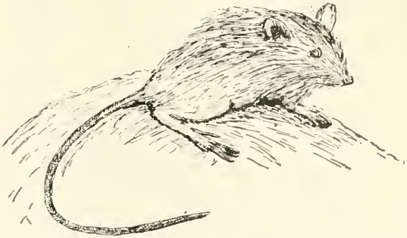


FIG. 318.—The jumping mouse, *Zapus hudsonius*.

The cottontail rabbit, gray gopher (Fig. 319), common shrew, jumping mouse (Fig. 318), chipmunk, and woodchuck (Fig. 320) are the commonest mammals of this forest margin association. Birds are particularly abundant, for the almost impenetrable growths of wild crab and hawthorn make safe nesting sites, while the cover is good for ground birds. Bobwhite, chewink, mourning dove, song sparrow, chipping sparrow, goldfinch, indigo bunting, catbird, brown thrasher, and shrike are all common in such haunts. Crabs and haws are blossoming in the spring in mid-May, at which time the warblers and vireos are passing over the Chicago region in great waves of migration. They are then attracted to the blossoming trees by the many insects that feed upon the blossoms.

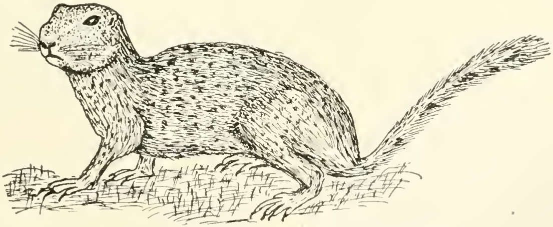


FIG. 319.—Gray gopher, *Citellus franklini*

Insect life is at all times abundant in this marginal association. The herbaceous plants of spring and midsummer mentioned above each attract a goodly number of characteristic guests, especially the thistles and the milkweed. The larva of the monarch butterfly is often found on the latter, and the red beetle, *Tetraopes tetraophthalmus*, is almost always present. Monarch, viceroy, anglewings, fritillaries, wood nymphs, the cosmopolitan (*Pyrameis huntera*), and painted lady (*P. cardui*) (Fig. 321) are common butterflies, the larvae of the two last mentioned feeding on the thistle. Hosts of flies, wasps, and bees feed on the blossoms, especially in the autumn when goldenrods and asters are the chief floral restaurants still open to hungry insects. Several orthoptera are characteristic, among

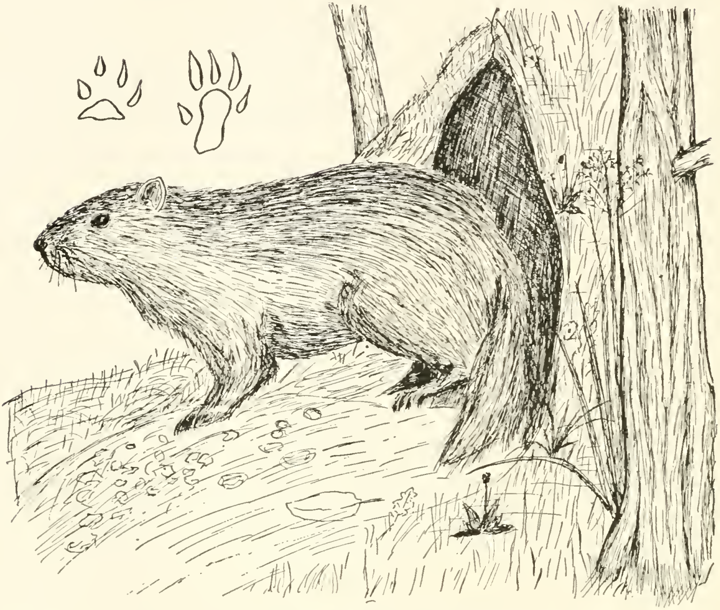


FIG. 320.—Woodchuck, *Marmota monax*, and footprints

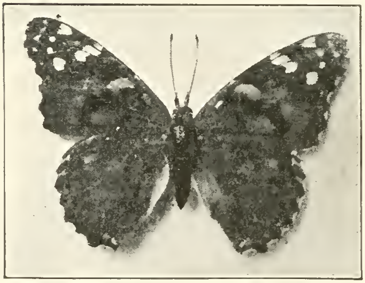


FIG. 321.—The painted lady, *Pyrameis cardui*.

which may be mentioned the tree crickets, *Oecanthus angustipennis*, *O. fasciatus*, and *O. nivens* (Fig. 300), and the round-winged and oblong-winged katydids (Figs. 322, 323); the short-winged locust, *Melanoplus scudderi*, the sprinkled locust, *Chloealtis conspersa* (Fig. 383), the sworded grasshopper, *Xiphidium ensiferum*, the woodland grasshopper, *Xiphidium nemorale.*

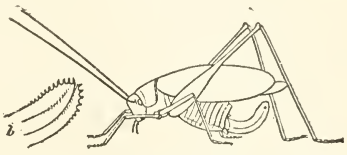


FIG. 322.—Round-winged katydid, *Amblycorypha rotundifolia; b,* tip of ovipositor. After Blatchley.

The tree crickets are gauzy-winged, pale green insects, whose stridulations make much of the insect music of late-summer nights. The oft-repeated buzzing notes, sounding in unison, with regularity, give a rhythmic pulsing volume of sound that keeps up from dusk to long past midnight. The short-winged locust is nearly an inch long. The color is reddish brown; the hind tibiae are bright red. The wing covers are short, about as long as the pronotum, the wings still shorter. Grasshoppers of the genus *Xiphidium* are small, but have a long ovipositor. The top of the head projects forward as a rounded prominence. The two species mentioned have bodies about one-half inch long and are greenish brown in color. The ovipositor of the sworded grasshopper is as long as the body; that of the woodland grasshopper is shorter and curved.

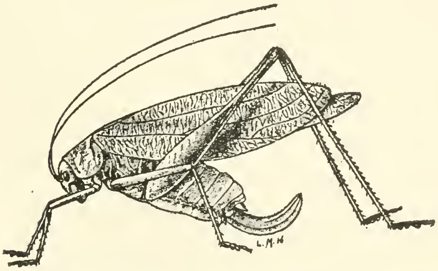


FIG. 323.—Oblong-winged Katydid, *Amblycorypha oblongifolia.* After Blatchley.

CHAPTER XI

LAKE TO FOREST OR PRAIRIE

AS WAS noted in discussing the interdunal ponds the ultimate fate of pond or lake is to be filled with the outwash of soil from the surrounding hills and the accumulations of vegetable débris. Such a filling lake may give rise either to (1) a forest, as shrubs and trees establish themselves in the firm soils of its rising margin and push their way farther and farther out as filling proceeds, or (2) to prairie. Indeed, these two associations, the wet forest and the low prairie, may develop at different parts of the same filling lake as is seen, for instance, at Wolf Lake near Chicago.

Beginning with the open water and running shoreward, the zones in the filling pond that lead to the forests might be named as follows: (1) open water area, or from the animals predominating, the Pleurocera area; (2) zone of submerged plants or the aquatic insect zone; (3) water lily zone or painted turtle zone; (4) the rush zone—the marsh wren zone; (5) the cat-tail zone—red-winged blackbird zone; (6) the shrub zone, the katydid zone; (7) the ash-elm zone, the green heron zone.

Out in the open water where the bottom is sandy, the water shallow and largely free from invading plants, caddis-fly nymphs are abundant, crawling over the bottom, as are also such snails as *Pleurocera* and *Goniobasis*, while *Vivipara contectoides* is occasionally found (Fig. 324). All three of these are operculate. In *Pleurocera* the aperture is produced into a canal. *P. elevatum* has nine to ten whorls, *P. subulare* twelve. *Goniobasis livescens* is broadly conical and the aperture is rounded in front. *Vivipara*

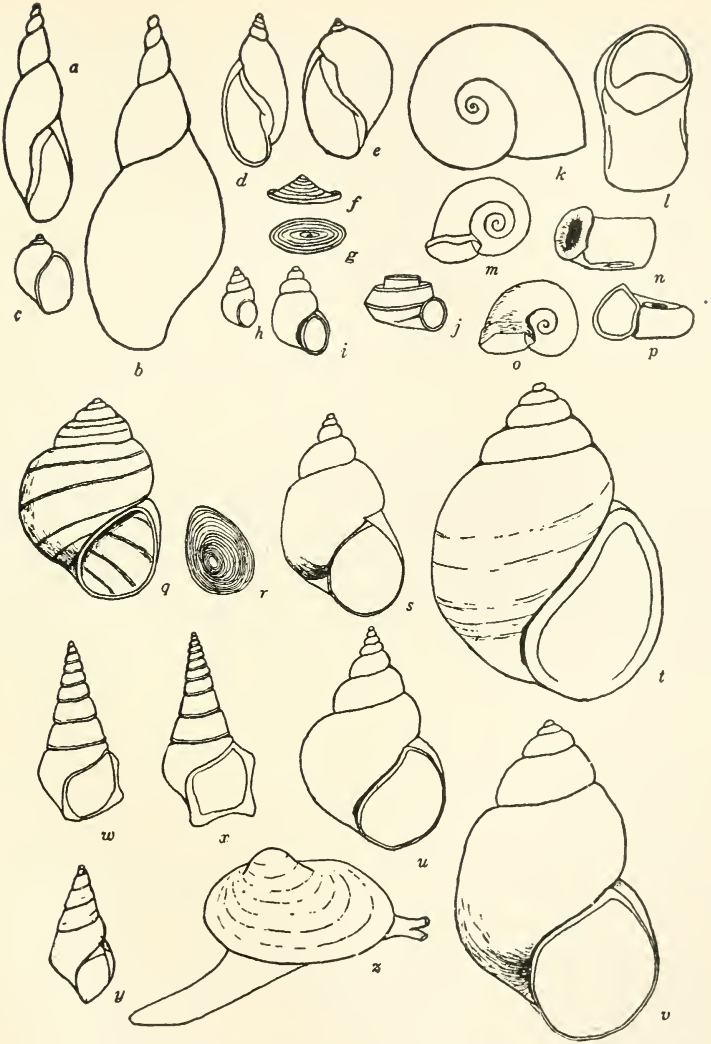


Fig. 324.—Water snails showing generic characters: *a*, *Lymnaea reflexa;* *b*, *L. stagnalis;* *c*, *L. woodruffi;* *d*, *Physa heterostropha;* *f*, *Ancylus fuscus*, side view; *g*, *Amnicola cincinnatiensis;* *i*, *A. emarginata;* *j*, *Valvata tricarinata;* *k*, *Planorbis trivolvis*, from above; *l*, *P. trivolvis*, side view; *m*, *P. campanulatus*, from below; *n*, *P. campanulatus*, side view; *o*, *P. bicarinatus*, from below; *p*, *P. bicarinatus*, side view; *q*, *Vivipera contectoides;* *r*, operculum of *V. contectoides;* *s*, *V. subpurpurea;* *t*, *Campeloma ponderosum;* *u*, *C. integrum;* *v*, *C. subsolidum;* *w*, *Pleurocera elevatum;* *x*, *P. subulare;* *y*, *Goniobasis livescens;* *z*, *Sphaerium transversum* (a clam).

contectoides is a large thin shell, banded or otherwise brightly colored. Here too are such clams as *Alasmodonta marginata* (Fig. 181) and *Lampsilis luteola* (Fig. 180). Some fairly good-sized fish come into the shallow area to lay their eggs in the sand of the bottom, such as the black bass, pumpkin seed (Fig. 188), bluegill (Fig. 187), perch, crappie (Fig. 438). The fish may often be seen, on careful approach, swimming in the neighborhood of the nest, especially the male that does guard duty until the young are hatched. In the very shallow water the blob or miller's thumb, one of the sculpins (Fig. 325); the blunt-nosed minnow (Fig. 429), straw-colored minnow (Fig. 436), and the Johnny darter (Fig. 429) are found and probably breed here. The crayfish, *Cambarus virilis*, is common, hiding under stones and logs.

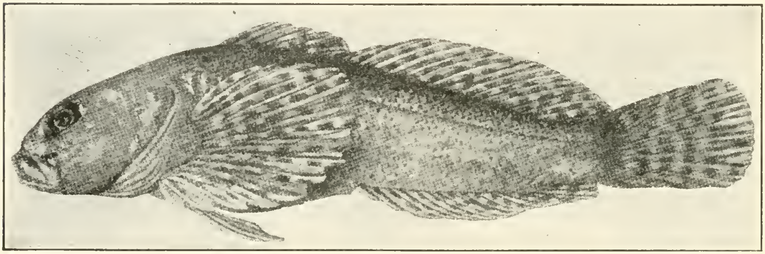
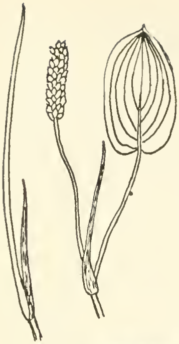


FIG. 325.—Blob, miller's thumb, or sculpin, *Cottus ictalops*. After Forbes

The waters of the lake are the habitat of many algae that grow in profusion, *Cladophora*, *Spirogyra*, *Oedigonium*, *Hydrodicton*, etc. They usually go under the common names of pond scums or water silk. Nearer shore there is an abundant floating vegetation consisting of such *Hepaticae* as *Riccia*, *Ricciocarpus* and flowering plants like the duckweeds. *Riccia* appears like a thick green leaf (really a thallus) about as large as your finger nail. There are short rootlike structures (rhizoids) given off from its under side. It floats on the shallow water or lies on the soft mud. Duckweed is also a floating plant with one or two tiny leaves and, for a short time in spring, a tiny blossom.



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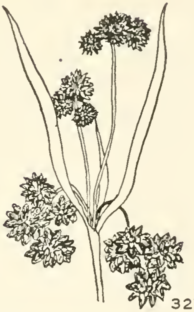

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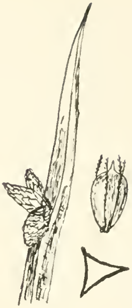

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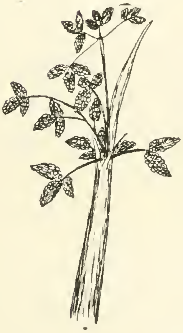

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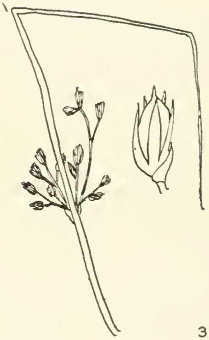

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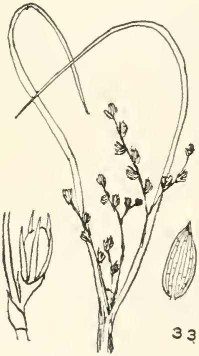

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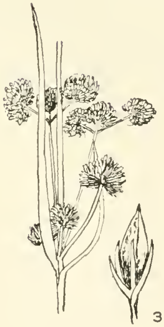

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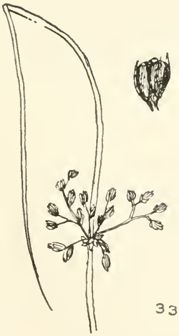

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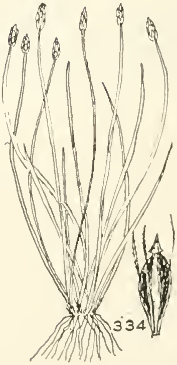

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FIGS. 326–334: Fig. 326.—One of the pond weeds, *Potamogeton natans;* Fig. 327.—A club rush, *Scirpus atrovirens;* Fig. 328.—*S. Torreyi;* Fig. 329.—*S. validus;* Fig. 330.—A bog rush, *Juncus balticus;* Fig. 331.—*J. tenuis;* Fig. 332.—*J. canadensis;* Fig. 333.—*J. effusus;* Fig. 334.—Spike rush, *Eleocharis acicularis.*

It bears a few, short, threadlike roots. The surface of the pond is often completely covered with this duckweed.

Many plants root in the soft bottom and grow more or less submerged; such are pondweed, *Potamogeton* of several species, as *P. natans, P. crispus, P. pectinatus, P. lucens, P. zosterifolius;* water milfoil, *Myriophyllum;* hornwort, *Ceratophyllum;* water weed, *Elodea;* tape grass, *Vallisneria;* bladderwort, *Utricularia;* water buttercup, *Ranunculus aquatilis* (Fig. 64).

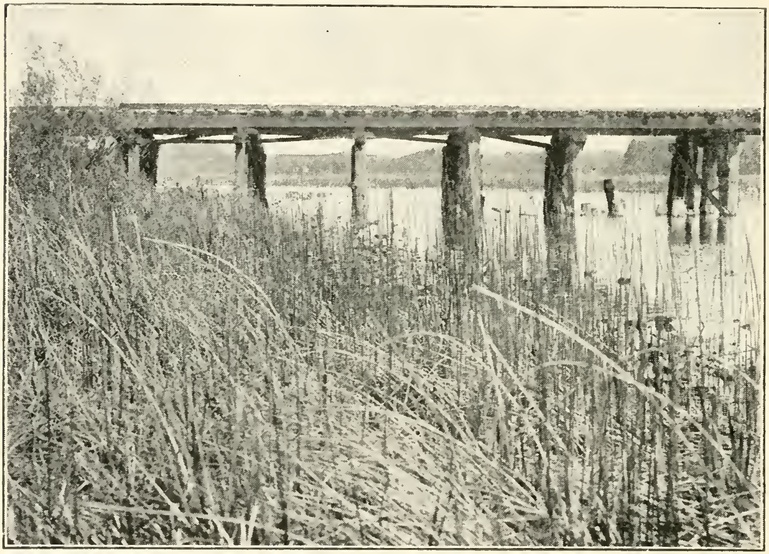
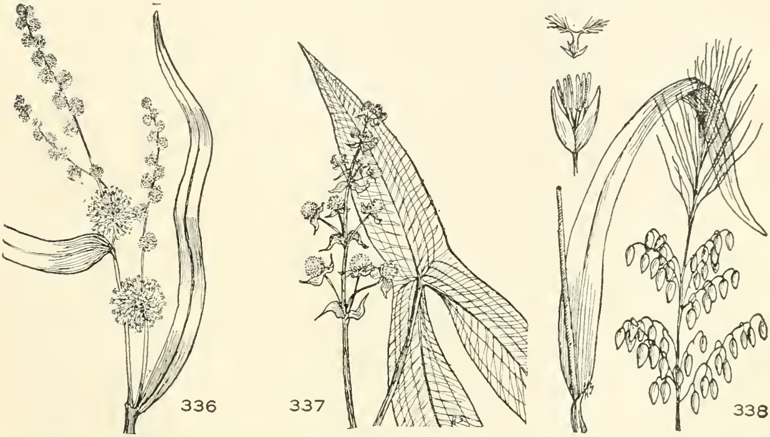


FIG. 335.—The bulrush zone, Galien River, New Buffalo, Michigan

Pondweed (Fig. 326) roots at the bottom of the pond and sends up its leafy stalk to the surface. Some of the leaves may lie on the surface of the water. Such are usually fairly firm and broad, while the submerged leaves are commonly narrow, translucent, and fragile. *Potamogeton natans* has egg-shaped floating leaves 1 inch or more long and very narrow, submerged ones less than .1 of an inch wide. *P. crispus* has only submerged leaves which are lance-shaped and are borne on short stems. The margins of the leaves are finely saw-toothed and crinkly.

P. pectinatus is entirely below water. Its leaves are long and narrow and are provided at the base with stipules which unite with the base of the leafstalk to ensheath the stem. Tape grass or eel grass has long, ribbon-like, narrow leaves, entirely below water or at times with the tips floating. The blossom is borne on a string-like stalk that is coiled at first to hold the bud below the surface and that uncoils and lets the blossom to the surface only while it opens long enough to permit of fertilization.



FIGS. 336–338: Fig. 336.—Bur reed, *Sparganium eurycarpum;* Fig. 337.—Arrowhead, *Sagittaria latifolia;* Fig. 338.—Wild rice, *Zizania aquatica.*

Then comes the water lily zone with water shield, *Brassenia purpurea;* lotus, *Nelumbo;* yellow and white water lilies.

Shoreward still farther comes the bulrush zone (Fig. 335), with *Scirpus lacustris*, *S. validus*, *S. atrocinctus*, *S. americanus*, *S. Torreyi*, *S. atrovirens* (Fig. 327), and other species; rushes of the genus *Juncus* like *J. balticus littoralis;* spike rushes like *Eleocharis acicularis*, *E. palustris*, etc. The bulrushes have, as a rule, long, tapering, solid round leaves sheathed at the base. The inconspicuous perfect flowers are borne in spikelets that are in some species solitary, in others clustered near the end of the leaf. Torrey's rush (Fig. 328) and the American rush are the only common ones in our neighborhood that have sharply triangular stems. The scales of the flower cluster in the former are reddish brown; in the latter, yellow brown. *Scirpus validus* (Fig. 329), the great bulrush, may be 8 feet high and proportionally lusty. The sheaths at the bases of the soft, light green leaves are soft and rather transparent. In *Scirpus atrocinctus* the bases of the bracts that are below the flower cluster are black.

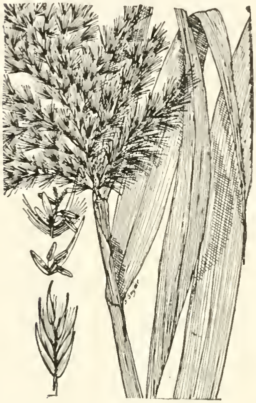


Fig. 339.—The reed, *Phragmites communis.*

In the bog rushes (*Juncus*) the flowers and fruits are not inclosed in husklike scales as they are in the bulrushes. The leaves are pithy or in some species hollow. The small flowers are clustered but not in spikes. The flower cluster appears to be on the side of the stem rather than on the end in *J. balticus* (Fig. 330). The plants appear in the latter species in rows arising from the underground stem. There are many other species such as *J. tenuis* (Fig. 331), *J. canadensis* (Fig. 332), *J. effusus* (Fig. 333).

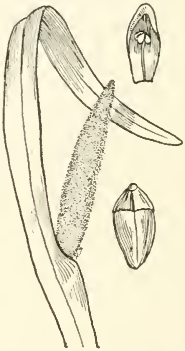


Fig. 340.—Sweet flag, *Acorus Calamus.*

Every stalk of the spike rushes ends in a spike of blossoms. The stalks are spongy inside. Those of *Eleocharis acicularis* (Fig. 334) are not over 4 inches in height (unless the plant is growing submerged), and hairlike, they are so fine. *Eleocharis palustris* is similar but stouter. Its stalks are cylindrical; its fruits, lenticular. The stalks of *E. acicularis* are more or less four-angled, and the fruits are triangular in cross-section.

Cat-tails come in next, the common, *Typha latifolia*, and the narrow-leaved, *T. angustifolia.* Then more or less mixed with the preceding plants come a number of marginal plants: bur reed (Fig. 336); arrowheads, *Sagittaria variabilis* (Fig. 337), and *S. heterophyla;* pickerel weed; wild rice (Fig. 338); water-reed, *Phragmites communis* (Fig. 339); sweet flag (Fig. 340).

Along the margin of the open water soft-shell, musk and geographic *turtles* are to be expected. The first is easily known by its leathery rather than bony shell; the second, by its musky odor; the third, by the fine lines on each bony plate of the shell that give an appearance something like a map. Farther in shore in the zone of submerged plants, especially in the bays, are many adult and larval insects that may be dredged up with the plants. The top minnow, *Fundulus dispar*, is common (Fig. 434). Among the insects are the water scorpion, giant water bug, water boatman, many diving beetles of the families *Dytiscidae* and *Hydrophylidae*, and May-fly nymphs. Dragon and damsel-fly nymphs are common, and the molt skins of the latter are commonly found on the rushes and cat-tails. A few of the more frequent dragon flies are *Anax junius*, *Gomphus spicatus*, and *Libullula pulchella*. These insect larvae are already familiar from the study of the interdunal ponds, as are also the

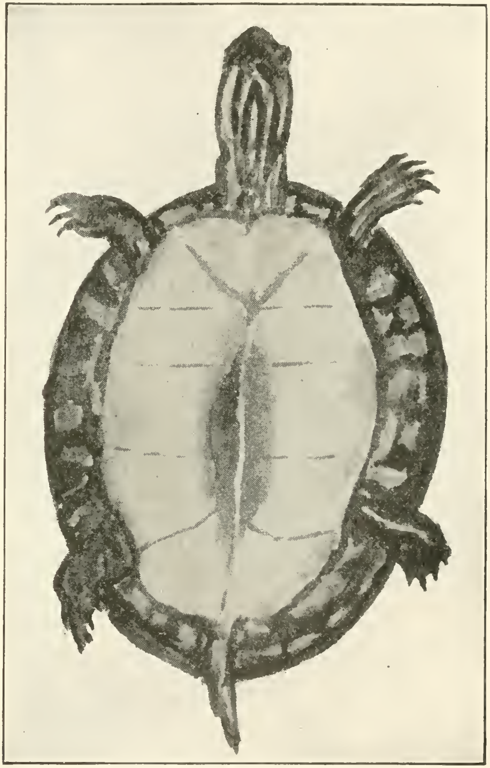


Fig. 341.—The painted turtle

snails, clams, and small crustaceans found abundantly here. In the zone of submerged plants the shrimp *Palaemonetes paludosus* (Fig. 56) is common, especially in the cooler waters. Here also one finds the large gelatinous masses inclosing colonies of the polyzoan *Pectinella magnifica.* Here, too, and in the zone of the water lilies, the painted turtle (Fig. 341) and the snapper (Fig. 342) are usually prevalent, and such frogs as the leopard, pickerel, green, and bull.

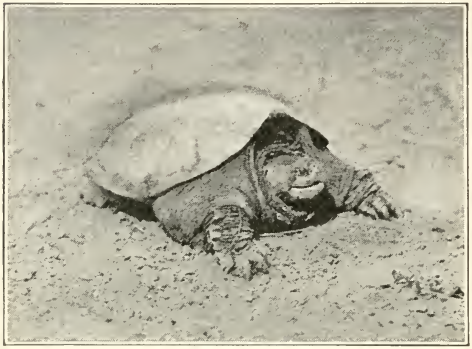


FIG. 342.—The snapping turtle

The bullfrog is known by his immense eardrums, much larger than his eyes (Fig. 343). The leopard frog is yellow below; above he is mottled with black blotches on a yellow ground. The pickerel frog (Fig. 344) is light brown, marked above with three rows of squarish blotches. The green frog is pale green above, marked with black blotches and is also pale green below.

The bulrushes afford nesting sites for the marsh wren, both long- and short-billed, that attach their globular nests to the rushes (Fig. 345), the black tern, the pied-billed grebe that build floating nests sometimes also in the cat-tail zone. In the cat-tail zone will be found nesting the red-winged and yellow-headed blackbirds, the American (Fig. 346) and least bitterns. The

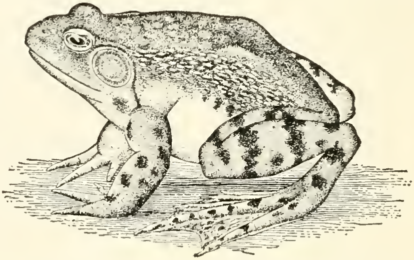


FIG. 343.—Common bullfrog, *Rana catesbeiana,* male. *Bulletin United States Fish Commission.*

first two attach their nests to the cat-tails which are fastened together in a loose cluster for the purpose. In these two zones one finds also Virginia, king, and sora rails, Florida gallinules, coots, herons, and sandpipers. The muskrat builds his dome-shaped house of the cat-tails, together with vegetable débris raked up from the bottom.

Pushing out from shore into the rush and cat-tail zone is the shrub zone. The buttonbush or elbowbush is the pioneer. Back of it comes such shrubs as prickly ash, an aromatic plant with odd pinnately compound leaves and prickers on the stems; maple-leaved viburnum, red-osier and silky dogwoods; and still farther back comes the white ash-elm forest association with the ash the predominant tree. Neither the ash-elm forest nor the shrub zone at its margin is marked by many strikingly distinctive animals. The black-sided grasshopper, *Xiphidium nigropleura*, is common on the shrubs and below them. The striped shrub crickets, the Texan katydid (Fig. 348), the oblong-winged katydid, and the forked-tail katydid (Fig. 347) are so prevalent that the shrub zone may justly be called the katydid zone. At times the larva of *Papilio cresphontes* is found freely on the prickly ash, as in the summer of 1921, but usually the giant swallowtail is rare about Chicago. When the shrubs are in blossom many gnats and flies are hovering about them, and

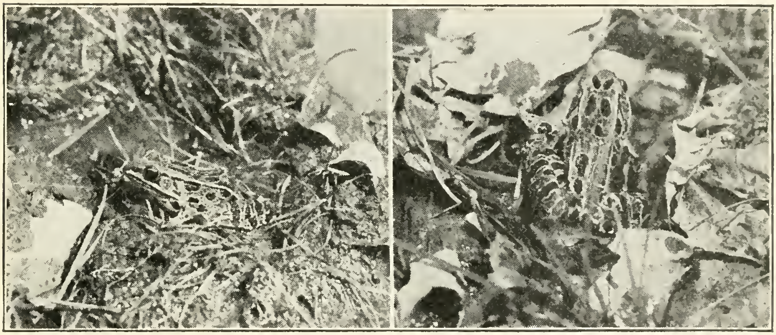


FIG. 344.—The pickerel frog

then the dragon flies that breed in the adjacent waters are busy hunting, flying with quick, darting movements along the open pathways.

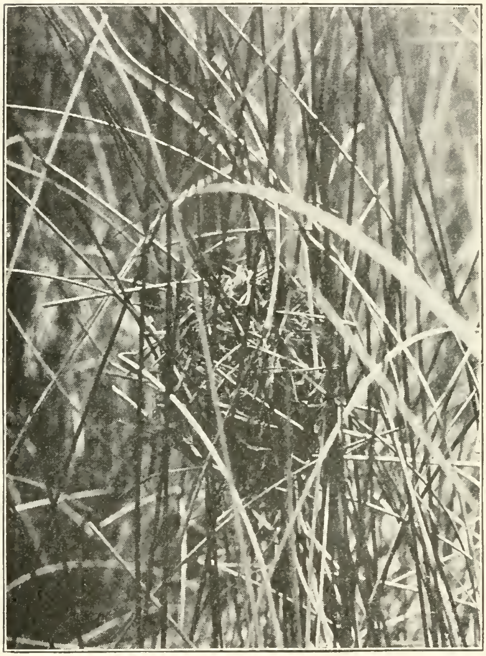


FIG. 345.—Nest of marsh wren, woven of marsh grass.

The ash-elm swamp forest is inhabited by many animals, few of which are, however, peculiar to it. Most of them are equally or even more prevalent in the elm-maple forest of the flood plain. The green heron often nests in the ash trees along the swamp margin and may be taken as the typical animal of this zone.

Not always does the filling of a low area in the Chicago region ultimately lead to a forest area. There is another association of plant and animal forms that seems to be the end result of such a process, namely, the prairie association. Extensive prairie areas have developed from the marshes that formerly occupied, and in part still occupy, the beds of the old lakes that formed back of the terminal moraines, such as the Morris Basin and the Kankakee Basin. They have developed also on extensive areas of sand that outwashed from the glacier and on upland regions in the moraines. Possibly the prairie finally transforms to forest, but if so the prairie stage in the development is a protracted one. It is difficult to decide just what it is that determines that one lake as it fills shall first give rise to marsh, then to swampy forest, later to the succession of oak and hickory forest, and finally to the climax forest, while another, after the marsh condition, proceeds through wet meadow to prairie. Possibly differences in depth of the original lake undergoing filling and consequent differences in the depth of humus, differences in drainage, in soil character, as well as other factors, enter into the production of unlike end results.

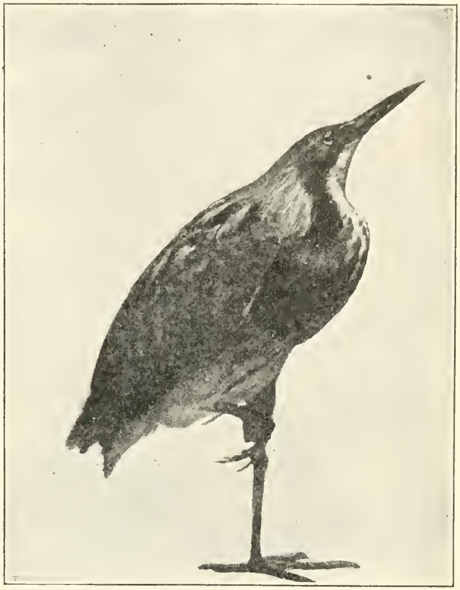
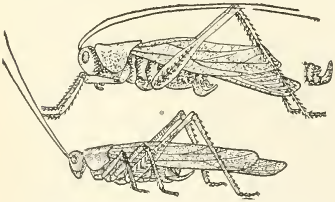
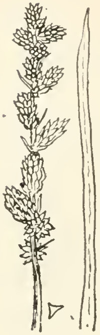


FIG. 346.—American bittern, *Botaurus lentiginosus.*

Once the differences between prairie and forest are established, it is easy to see enough contrasts in atmospheric and soil temperatures, in water content of the soil, in relative percentage or saturation of the atmosphere, to account in part, perhaps entirely, for the very different plants and animals in the two regions. The temperatures in the soil and among the vegetation of the forest are not subject to such extremes, either seasonal or diurnal, as on the prairie. The temperature in the forest and in its soil is lower in summer and at midday than on the prairie. The cool air protected in summer by the forest trees is a much



FIGS. 347, 348: Fig. 347 (top).—Forked-tail katydid, *Scudderia furcata;* Fig. 348 (bottom).—Texas katydid, *S. texensis.*



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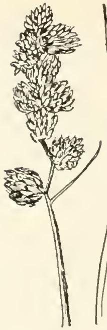

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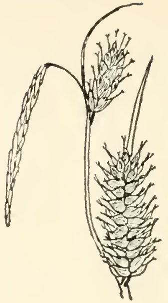

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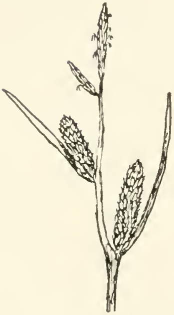

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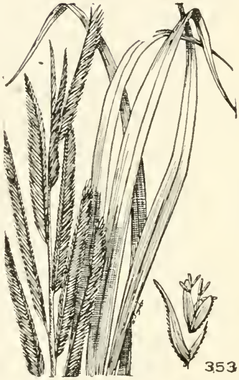

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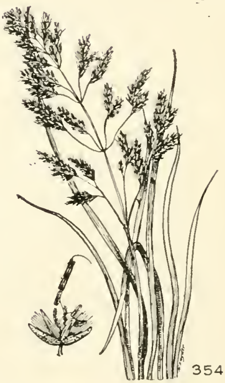

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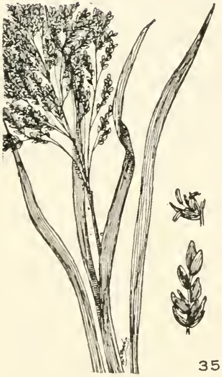

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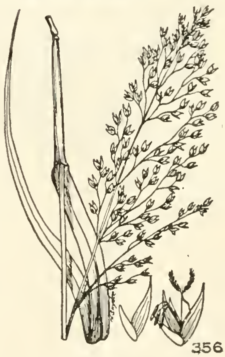

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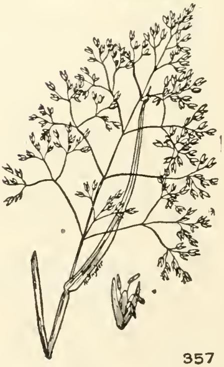

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FIGS. 349–357: Fig. 349.—*Carex conjuncta;* Fig. 350.—*C. cristata;* Fig. 351.—*C. lupuliformis;* Fig. 352.—*C. stricta;* Fig. 353.—Slough grass, *Spartina Michauxiana;* Fig. 354.—Blue-joint grass, *Calamagrostis canadensis;* Fig. 355.—Fow meadow grass, *Glyceria nervata;* Fig. 356.—Switch grass, *Panicum virgatum;* Fig. 357.—Thin grass, *Agrostis perennans.*

deeper layer in the forest than in the corresponding layer in the relatively short vegetation of the prairie. The forest atmosphere is more humid than that of the prairie. Evaporation is relatively greater on the prairie.

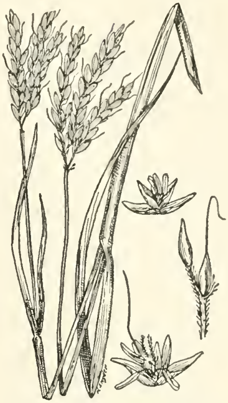


FIG. 358.—*Andropogon furcatus.*

Most of the original prairie has passed under cultivation, and the prairie flora and fauna have largely been obliterated. Scattered remnants of it persist, a few plants and the associated animals surviving in this locality, a few others elsewhere. But in few if any localities is the old wealth of prairie forms to be encountered in anything like its early luxuriance. Probably along the rights of way of the railroads the prairie forms are found more abundantly

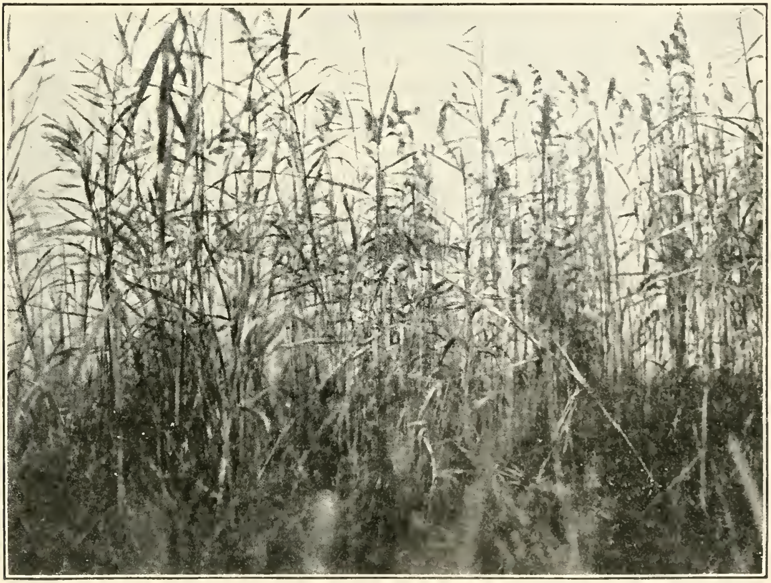


FIG. 359.—Luxuriant grasses of wet prairie

than anywhere else. There are stretches where the traveler catches glimpses of the carpet of brilliant and varied blossoms that once spread far and wide and of the teeming animal life that accompanied the prairie plants. It well repays the effort to trace the evolution of the prairie and to become acquainted with the typical plants and animals of this prairie association in as favorable localities as are at present available.

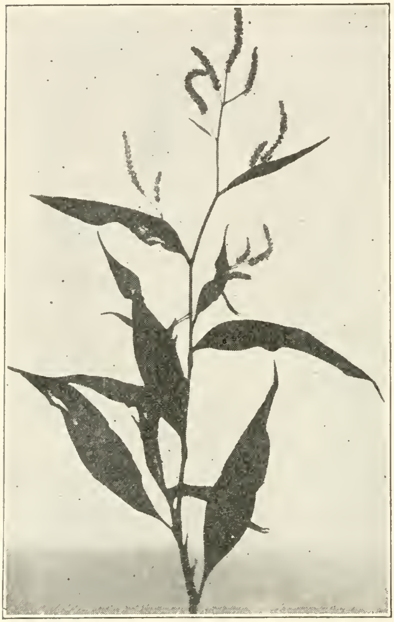


FIG. 360.—Smartweed, *Polygonum lapathifolium*.

Shoreward from the rush zone in those lakes or portions of lakes that are developing into prairie there comes a broad zone occupied by sedges and grasses. The cattail zone is omitted. This sedge zone is more or less completely inundated in the high-water stages of early spring, but in the summer may be reasonably dry. Here such sedges as *Carex aquatilis*, *C. conjuncta* (Fig. 349), *C. cristata* (Fig. 350), *C. lupuliformis* (Fig. 351), *C. riparia*, and *C. stricta* (Fig. 352), together with some of the rushes of the preceding zone, are found. The *Carexes* are grass-like plants usually with triangular stems. There are very many species, a few of which may be recognized by the figures. Gray's *Botany* will be needed to determine the many others. Such grasses as the following are distinctive. They are named in the order of their appearance from the outer edge of the zone shoreward: slough grass (Fig. 353), blue-joint grass (Fig. 354), fowl meadow grass (Fig. 355), switch grass (Fig. 356), thin grass (Fig. 357), *Poa triflora*, etc. Sampson thinks the first five are the typical and most characteristic ones in the succession that leads to the occupation of the prairie by the *Andropogon furcatus* (Fig. 358), which marks the climax. In summer these swamp grasses may be luxuriant enough to pay for cutting to secure the coarse marsh hay (Fig. 359).

Among the grasses and sedges occur many other plants, not in masses so as to give character to a whole zone as do the grasses and sedges, but still frequently. The fern, *Aspidium cristatum*, is a common one in such marsh lands. *Equisetum*

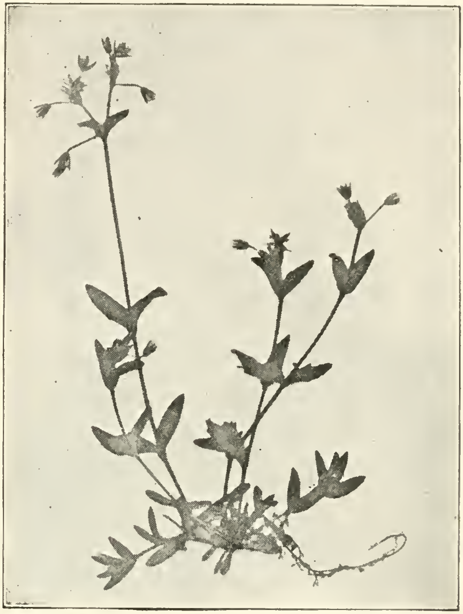
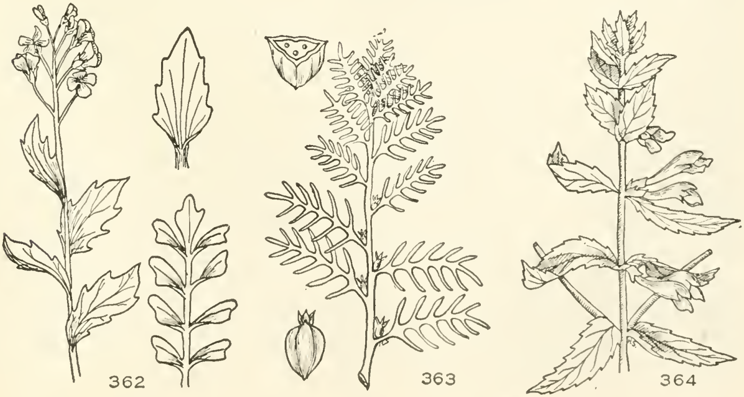


Fig. 361.—Chickweed, *Cerastium vulgatum*



Figs. 362–364: Fig. 362.—Three species of *Cardamine: C. Douglassii* at left; leaf of *C. bulbosa*, above at right; *C. pennsylvanica*, right below; Fig. 363.—Mermaid weed, *Proserpinaca palustris;* Fig. 364.—Skull cap, *Scutellaria galericulata.*

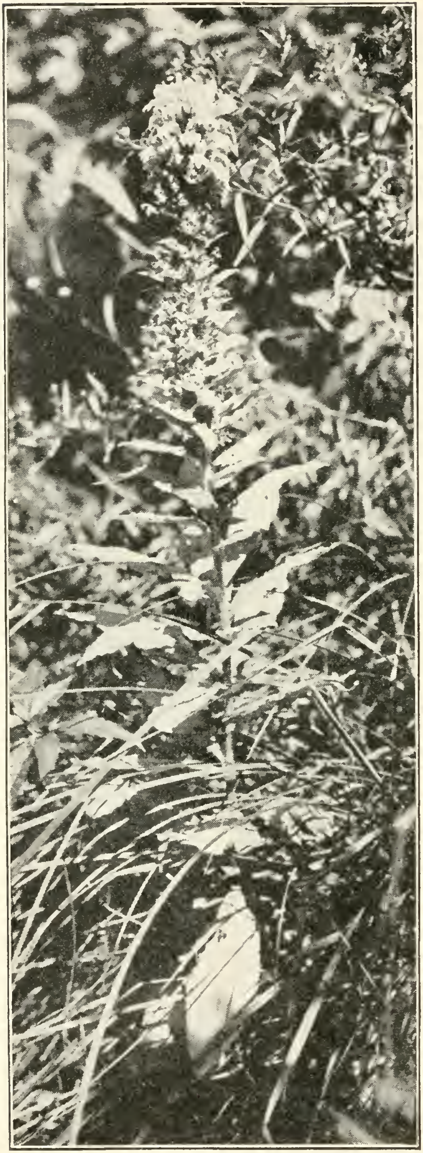


Fig. 365.—Cardinal flower, *Lobelia cardinalis*.

fluviatile is prevalent. Other forms are smartweeds, *Polygonum lapathifolium* (Fig. 360) and *P. persicaria*, chickweed (Fig. 361), bitter cress (Fig. 362), *Viola blanda*, mermaid weed (Fig. 363), skull cap (Fig. 364), cardinal flower (Fig. 365).

The grass and sedge formation described above may give place to the prairie, at first to the wet prairie and finally to the typical upland prairie. Both of these areas manifest marked seasonal changes as indeed do most areas. One set of plants comes on to maturity, blossoms, fruits, and gives way to a later set, which in turn becomes inconspicuous as some other assumes for the time being the conspicuous rôle. Thus *Viola blanda* and *V. pedatifida* blossom early on the prairie, shooting star (Fig. 366) comes then, wild hyacinth (Fig. 367) by June, then wild onions (Fig. 368), Culver's root (Fig. 369) and golden old man (Fig. 370) follow. Brown-eyed Susans

(Fig. 371) are pre-empting attention by July, as are also the cone-flowers (Fig. 372); the purple ones are notably brilliant. Then in late summer come blazing stars (Fig. 133), rosin weed (Fig. 373), asters, goldenrods, and beggar-ticks, whose fruits you carry away as souvenirs *nolens volens.* The above-mentioned plants, because they are conspicuous when in blossom, give a constantly changing character to the prairie, yet, after all, the dominant things are the prairie grasses such as blue-stem, *Andropogon furcatus*, and dropseed, *Sporobolus cryptandrus* (Fig. 374), that by their very abundance and uniformity fail to strike attention.

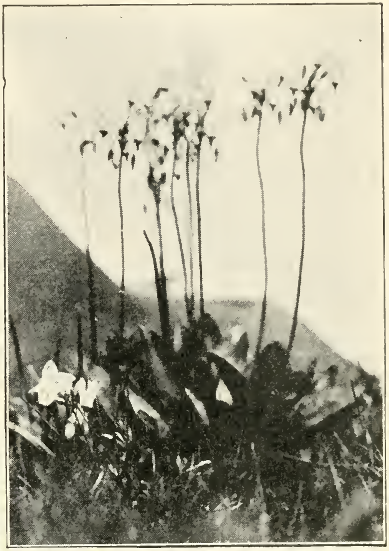


Fig. 366.—Shooting star, *Dodecatheon meadia.*

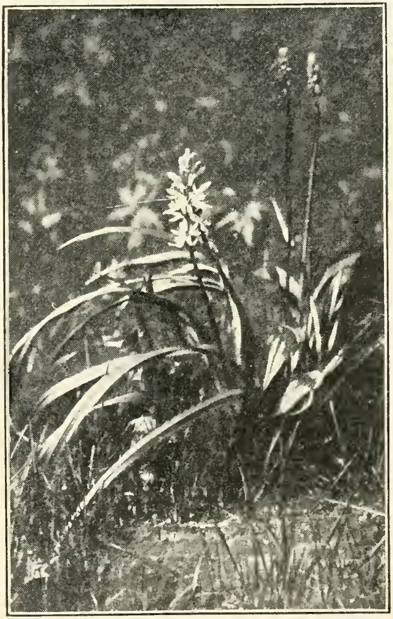


Fig. 367.—Wild hyacinth, *Camassia esculenta.*

As the prairie with dominating clay soil becomes pretty dry such plants as the rose pink prairie phlox (Fig. 375), prickly lettuce (Fig. 62), butterfly weed, prairie thistle, everlasting, rattlesnake master (Fig. 376) become more conspicuous, replacing in part the above-mentioned forms. On thin-soiled prairie, or prairie with sandy soil, the pink and white prairie clover, *Petalostemum* (Fig. 377), and lead plant (Fig. 378) are apt to predominate, while such typical plants of the clay-soil prairie as *Silphium terebinthinaceum*, *S. laciniatum*, and *Eryngium yuccifolium* are rare.

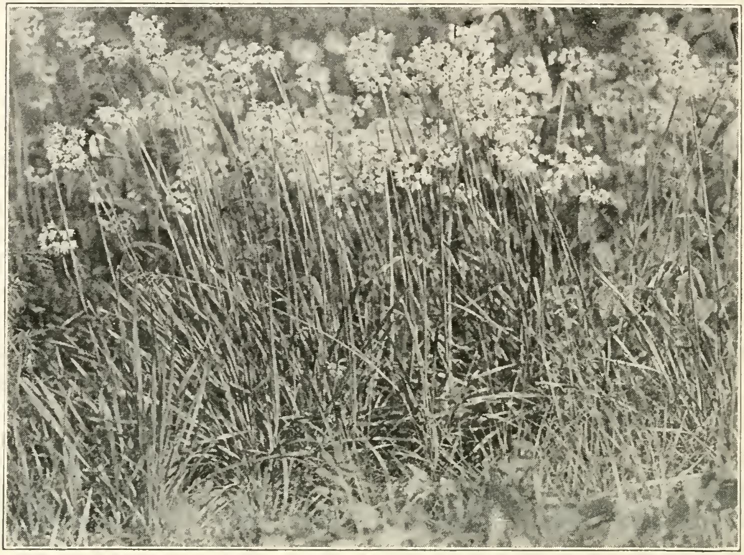


FIG. 368.—Wild onion in blossom, *Allium cernuum*

Naturally in any region with as distinctive a group of plants as exists in the prairie there will be a characteristic assemblage of

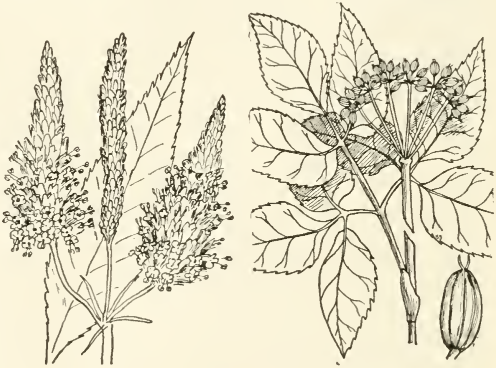


FIG. 369 FIG. 370

FIGS. 369, 370: Fig. 369.—Culver's root, *Veronica virginica;* Fig. 370.—Golden old man, *Zizia aurea.*

animals. Indeed, the transition, as one goes from the oak-hickory or the maple-beech forest to the adjoining prairie, is so abrupt, the new animals and plants so strikingly dissimilar to those of the forest, that even the casual observer must be struck by the change. The contrast is even enhanced by going through the border of wild shrubs, hawthorn, trembling asps, and sumacs, so characteristic at the edge of the oak-hickory association with the distinctive animal and plant life that belongs to such a border.

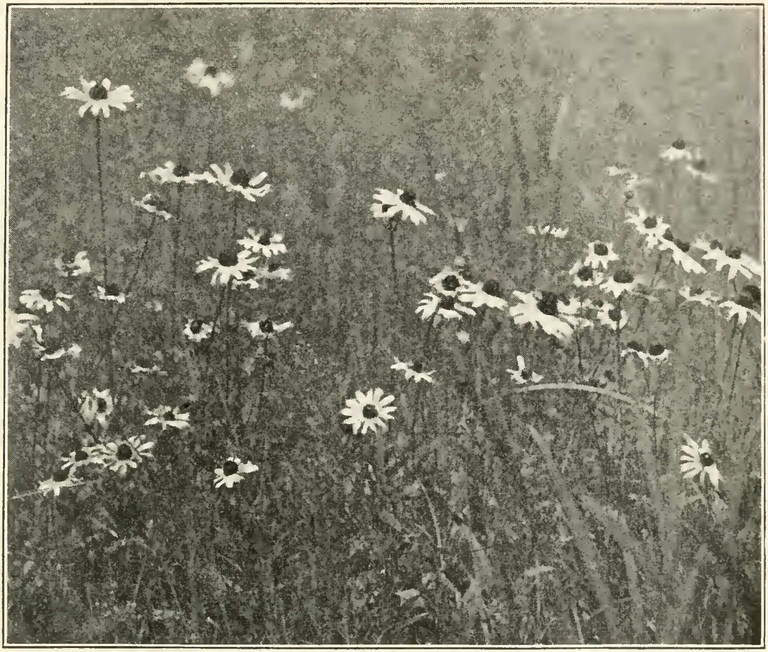


Fig. 371.—Brown-eyed Susans, *Rudbeckia hirta*

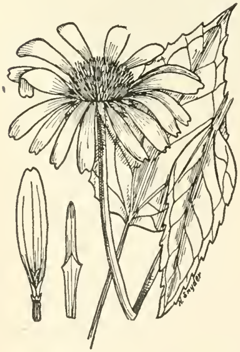


Fig. 372.—Coneflower, *Brauneria purpurea.*

One of the most characteristic features of the wet prairie or even of the upland

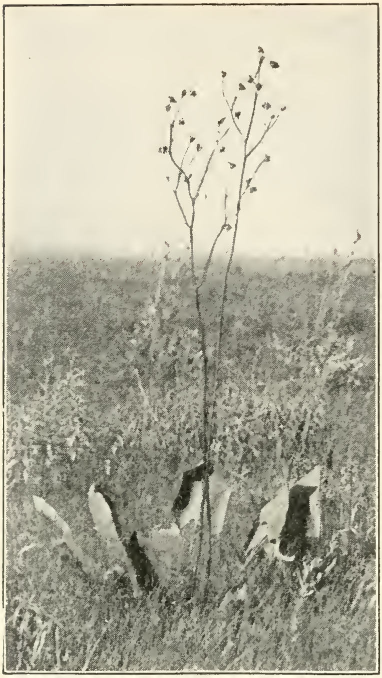


Fig. 373.—Rosinweed, *Silphium terebinthinaceum*.

prairie, if its subsoil is clay, is the abundance of chimneys of the burrowing crayfish, *Cambarus gracilis* (green) (Fig. 379) and *C. diogenes* (red). These animals dig wells to insure moist retreats in the dry summertime and safe ones at all times. The excavated material is often piled as a chimney about the hole. The crayfish lives near the top of the burrow but drops back when frightened. He wanders out from his castle turret to seek food, hunting largely at dusk. Earthworms are common in the rich prairie soils, particularly the big night crawler. Larvae of the June beetle are abundant in the subterranean layer of the upland prairie. The ant, *Formoso subpolitavar neogagates*, builds large hills, burrowing into the ground beneath them. The star-nosed mole, similar to the common mole, but easily recognized by its large front feet with heavy claws and the fringed disk on its nose, burrows beneath the sod for worms and larvae. The familiar striped gopher

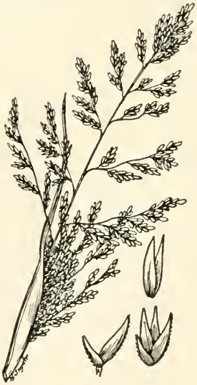


Fig. 374

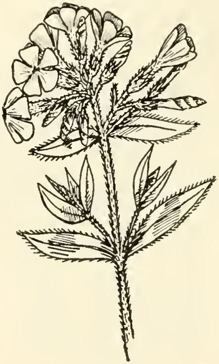


Fig. 375

Figs. 374, 375: Fig. 374.—Dropseed grass, *Sporobolus cryptandrus;* Fig. 375.—Prairie phlox, *Phlox pilosa*.

(Fig. 380), ground squirrel, or thirteen-lined spermophile, and *Franklin's spermophile* or gray gopher (Fig. 319), dig their retreats here and scurry to them from their foraging trips. The pocket gopher (Fig. 381) is also a resident of the high prairie. The bulging cheek pockets stored with food characterize this little rodent.

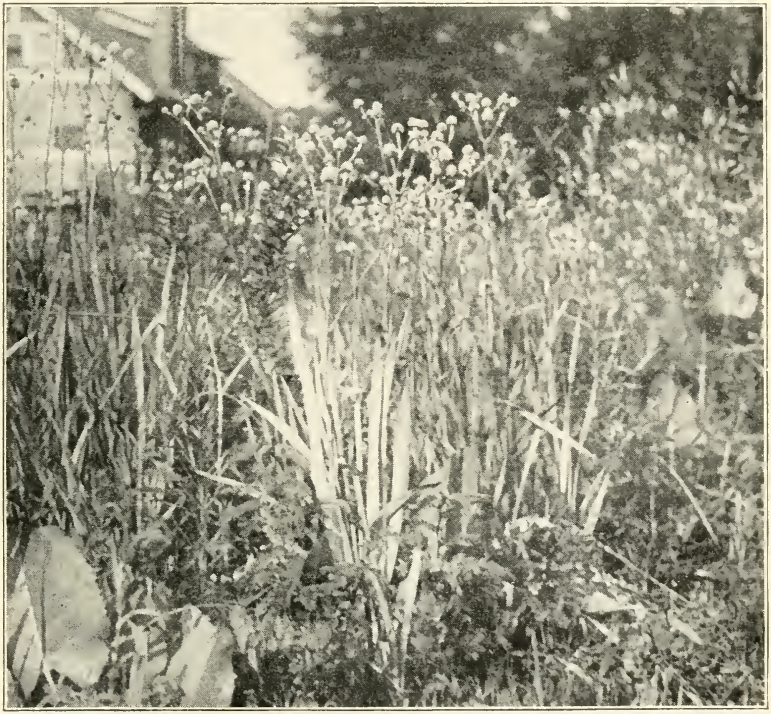


FIG. 376.—Rattlesnake master, *Eryngium yuccifolium*

The field mouse, *Microtus ochrogaster*, builds its nest of grass, sometimes hiding it under a log in the adjacent forest. It lives by hunting for provender among the grasses. It is similar to the Pennsylvania meadow mouse (Fig. 382) but has a gray-brown back, while the Pennsylvania meadow mouse has a dark brown back. The prairie deer mouse, 5.25 inches long, gray-brown above, white below, with gray feet and white toes, is fairly common. It is quite like the white-footed deer mouse (Fig. 287) but this has pure white feet. The Pennsylvania meadow mouse is more prevalent in the wet prairie. Certain birds nest on the ground of the open prairie; the most characteristic are the bobolink, the meadow lark, its nest at the end of a grassy tunnel, the dickcissel, the vesper sparrow, the grasshopper sparrow, the prairie horned lark, the lark bunting, and the prairie chicken. The first three mentioned

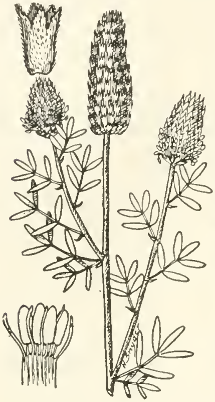


FIG. 377

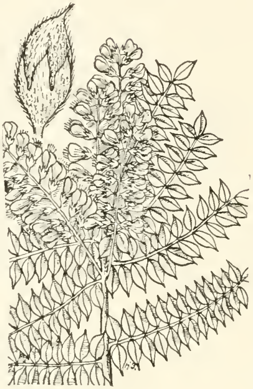


FIG. 378

FIGS. 377, 378: Fig. 377.—Prairie clover, *Petalostemum purpureum;* Fig. 378.—Lead plant, *Amorpha canescens.*

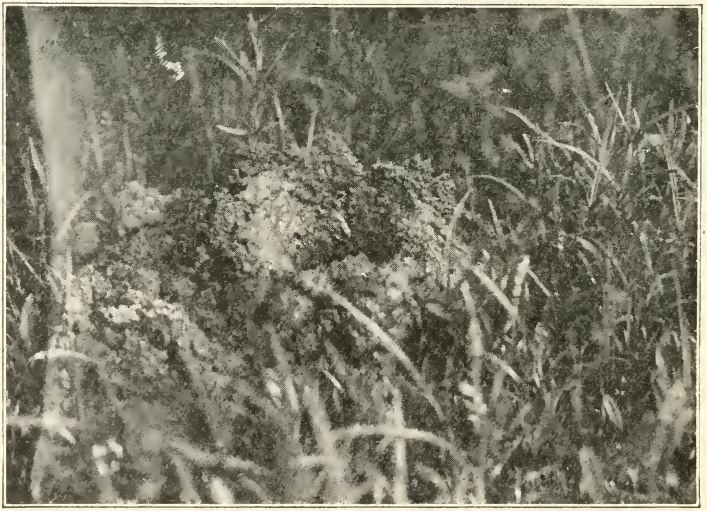


FIG. 379.—Chimney of burrowing crayfish, *Cambarus diogenes*

are found most often in the wet prairie; the others belong to the dry prairie association. Prairie horned lark and lark bunting are not very common residents of the Chicago region.

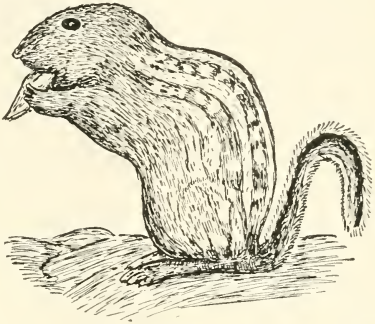


FIG. 380.—Striped gopher, *Citellus tridecemlineatus.*

The common toad is prevalent, as would be expected, in a region where insects are so common. The green snake, *Leiopellis vernalis*, green above, greenish white below, is the characteristic snake, especially in the moist prairie, while the prairie garter snake is more common on the dry prairie, though becoming rare.

The short wing and the long-winged grouse locusts, *Tettigidea parvipennis*, *T. pennata*, live on the ground of the wet prairie. They are small, obscure because of their ground color, and appear in the spring. Later these small forms give place to the more familiar locusts and grasshoppers of the summertime. The characteristic ones of the wet prairie are *Xiphidium fasciatum*, the red-legged locust (Fig. 383), the two-lined locust (Fig. 383), and the short-winged

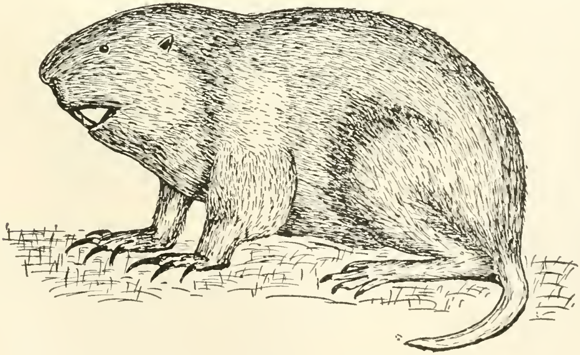


FIG. 381.—Pocket gopher, *Geomys bursarius*

locust (Fig. 383). Those of the dry prairie are the field grasshopper, the glade grasshopper, the straight-lance and the meadow grasshopper (Fig. 383).

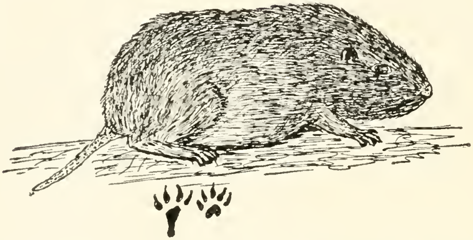


FIG. 382.—Pennsylvania meadow mouse, *Microtus pennsylvanicus*, and footprints.

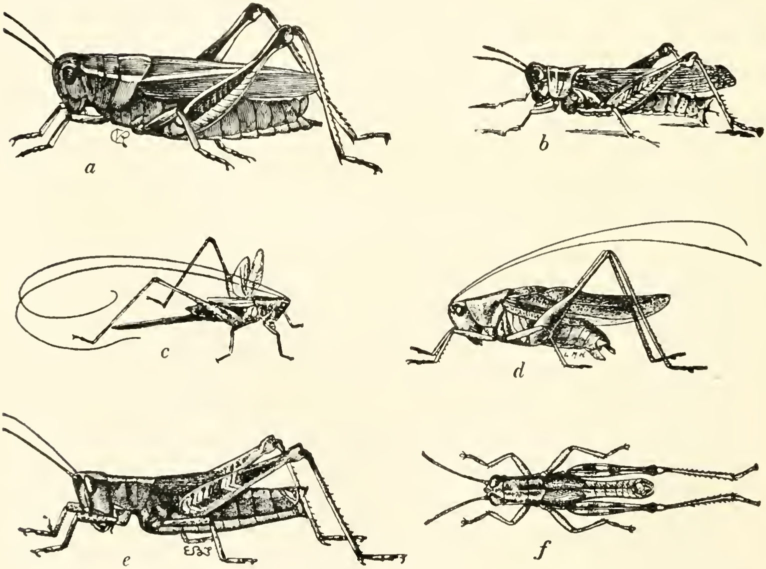
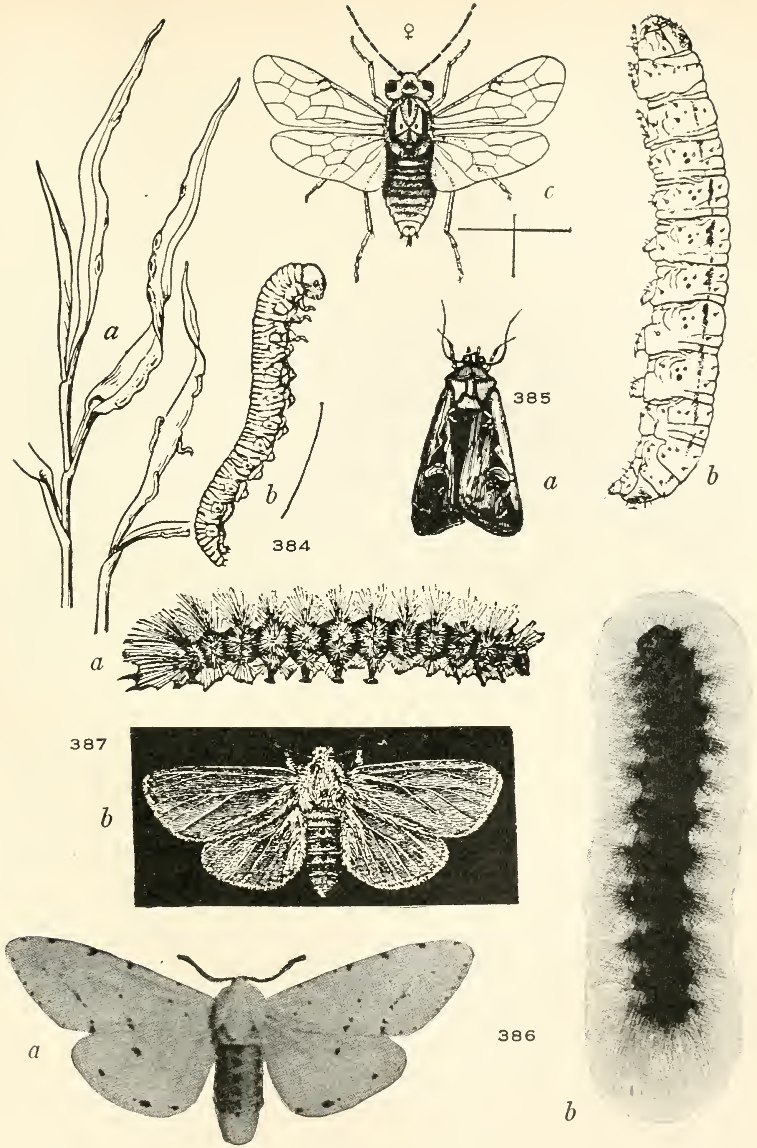


FIG. 383.—Different species of grasshoppers: *a*, the two-lined locust, *Melanoplus bivittatus; b*, the red-legged locust, *M. femur-rubrum; c*, the short-winged meadow grasshopper, *Xiphidium brevipenne; d*, the common meadow grasshopper, *Orchelmium vulgare; e*, the sprinkled grasshopper, *Chlocaltis conspersa; f*, the green-legged locust, *Melanoplus viridipes*.

Many larvae are found feeding on the grasses and associated plants, particularly on the low prairie where such plants remain



Figs. 384–387: Fig. 384.—Grass sawfly (*a*), larvae on grass; (*b*), larva enlarged; (*c*), adult female. After Marlatt; Fig. 385.—Dingy cutworm (*b*) and moth (*a*), *Feltia subgothica*. After Felt; Fig. 386.—Salt-marsh caterpillar and moth, *Estigmena acraea*. After Forbes; Fig. 387.—The "yellow bear" (*a*) and moth (*b*), *Diacrisia virginica*. After Forbes.

succulent for a long time. Sawfly larvae (Fig. 384) appear late in the spring. Moth and butterfly larvae are common, as are also the adults. The cutworm moth (Fig. 385) flies out of the short grass in the early spring and remains abundant all summer. Its larvae feed on the wild strawberry plant. The salt-marsh caterpillar (Fig. 386) and the "ghost moth" that comes from it, the "yellow bear" (Fig. 387), and the hedgehog caterpillars and their moths, including the Isabella moth, the caterpillar of which is known as the "woolly bear" (Fig. 388), are common in all seasons, the caterpillars especially so in the fall.

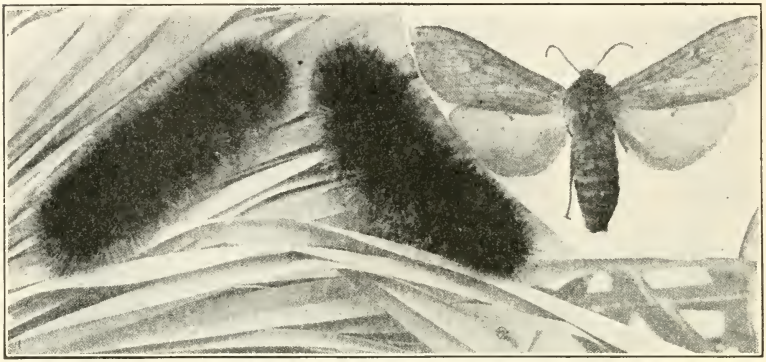


FIG. 388.—The Isabella tiger moth, *Isia isabella*, and its larva, the "woolly bear" caterpillar, from *Cornell Nature Leaflet*.

Then every plant of the prairie has its associated animals, so a succession of animal forms appears as the spring plants give place to the summer ones and these in turn to the autumn types.

CHAPTER XII

LAKE BLUFF, RAVINE, AND RIVER VALLEY

PRAIRIE and climax forest, once established, are not assured of permanency. Indeed, the forces that operate to destroy them are often at work contemporaneously with those that complete their formation.

Along the lake shore wave action is in many places undercutting the bluffs so that adjacent forest or prairie is sliced off gradually to disappear in the insatiable maw of the lake. The plant and animal life of this unstable bluff side is quite different from that of the prairie or forest it replaces. Again, a runnel starts in the spring freshets, courses through the prairie or the forest, excavating a slight depression. Year after year this deepens and widens so that the prairie or woodland is invaded by a growing ravine that produces extensive changes in the flora and fauna. In time the ravine widens to a miniature river valley. It is interesting to trace these changes produced as bluff and ravine and river valley develop.

The annual winter storms cut away the underpinning of such bluffs, the upper portions slide down, carrying trees and shrubs from the higher level to destruction in the wave-washed base (Fig. 1). Naturally, few plants and animals can maintain existence in such an unstable environment. The surface of such a bluff is often largely free from vegetation or scantily covered at best with such forms as can maintain a temporary footing on the insecure soil.

Moreover, such nearly naked bluffs have a high rate of evaporation. The upper portions especially are dry because the soil water drains out so readily. They are exposed, too, to the cold winds from the lake. It is to be expected, therefore, that the plants, especially of the crest, will be xerophytic and hardy (Fig. 389). White pines, jack pines, cottonwood, large- and small-toothed aspens, red cedar, white birch, spreading juniper, leatherleaf, red-osier dogwood, glaucous willow, and staghorn sumac are the characteristic shrubs and trees on those bluffs that are somewhat stabilized. Sweet clover and many other common weeds that can stand severe exposure are found, such as mullein, Canada thistle, dock, Russian thistle, the horsetails, *Equisetum hyemale* (Fig. 390), and *E. arvensis*.

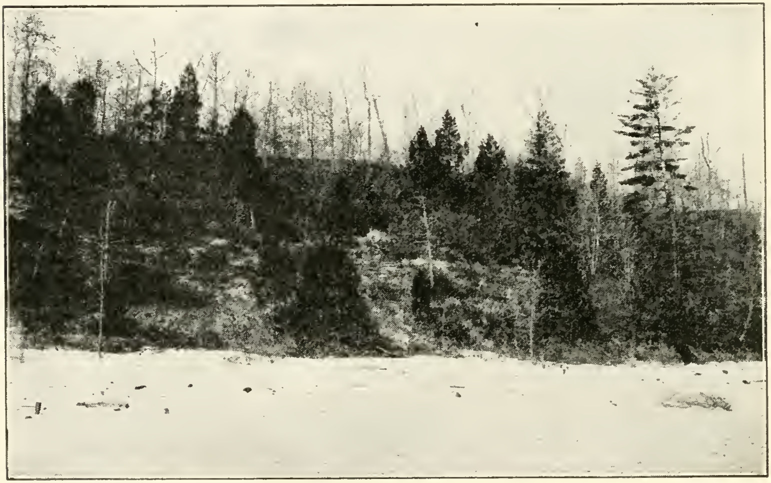


Fig. 389.—Lake shore bluff with xerophytic vegetation

The animal life is scant but is as distinctive as the plant. As in the Dunes we found a tiger beetle, characteristic of nearly every zone, so here we find *Cicindela purpurea limbalis* (Fig. 145) confined to this particular habitat, chiefly on the wet clay bluffs. The holes of the larvae are common on bare spots, and the adults are abundant in midsummer, hunting over the sparse vegetation for insect prey, particularly the sweet clover. The clay-bank spider, a large black one, *Pardosa lapidicina* (Fig. 391), shares this hunting ground. Some clay-bank wasps hunt here, and the Carolina locust is common. Wherever the cliff is stable enough to develop shrubs and tree thickets the plants and animals of the mesophytic forest margins appear (see p. 230).

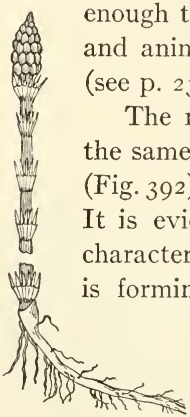


FIG. 390.—Common scouring rush, *Equisetum hyemale.*

The ravine in clay soil attains at its mouth much the same appearance as does the lake shore clay bluff (Fig. 392), and the animals and plants found are similar. It is evident, however, that the ravine will vary in character according to the sort of material in which it is forming. In loose and friable soil it will develop rapidly, its sides will wear by erosive action with celerity, and it will in a relatively short time be broad in comparison with its depth, so its sides will have gradual slopes. In clay soil, however, the stream cuts into the more resistant material more rapidly than the less vigorous agents of erosion, atmospheric disintegration, rain, and wind affect the sides. The ravine, therefore, will be deep in comparison with its width and will have steep slopes (Fig. 6). In rock only the stream is powerful enough to erode rapidly. The sides wear away very slowly, so the rock ravine has very steep, often vertical, sides. Ravines of the first type, hardly ravines at all, but miniature valleys, are wide open to the sun, so that light, heat, and the rate of evaporation is much as it is elsewhere in the vicinity. The slopes are dry, however, since water runs off them well and seeps out into the lower stream bed. But in ravines in clay soil the sun has access only at certain times of the day; they are, therefore, cool

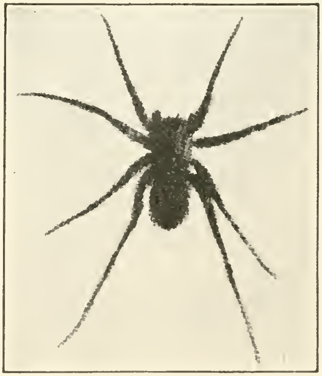


FIG. 391.—Clay-bank spider, *Pardosa lapidicina.* After Shelford.

and moist. Evaporation goes on very slowly. These same conditions prevail even in a more emphatic manner in the rock ravine. In the latter type especially, springs emanating through rock cracks and crevices often keep the sides dripping wet.

The ravine is naturally most completely developed at or near its mouth, for it was at this end that it began cutting back into the highland. At its head it is still a young ravine, pushing back gradually into the prairie or forest. As one follows down the ravine older and older stages are encountered. At first it is a mere gully with a tiny trickle in it, except during spring freshets. Then it deepens and widens into a young V-shaped ravine with a growing stream as tributary gullies add their contributions. In clay and rock the sides are very steep—so steep that the rock or clay slides down in landslides into the bottom, often producing bare areas so unstable that plants cannot get a foothold. Still farther down the growing brook begins to cut into one side, then the other, as it assumes a tortuous course due to varying obstructions. So the stream meanders

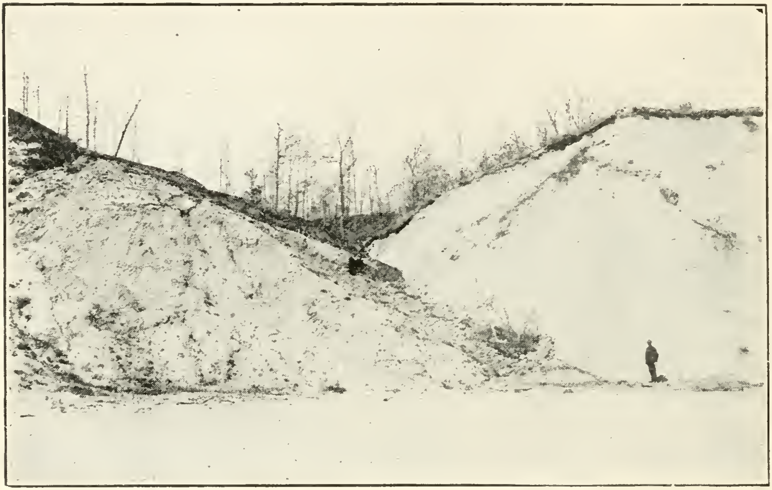


FIG. 392.—Mouth of ravine at the lake shore

back and forth, depositing in some spots what it wears away in others. The bottom of the ravine widens into a miniature flood plain. The sides become less steep. Possibly in the lower reaches the stream has cut down nearly to the level of the lake or larger stream into which it flows and so runs sluggishly. It is no longer a brawling brook, but a placid little creek. The ravine has broadened into a miniature valley. All these stages are admirably seen along the north shore of the lake where the clay bluffs abut upon the shore (Figs. 5 and 6).

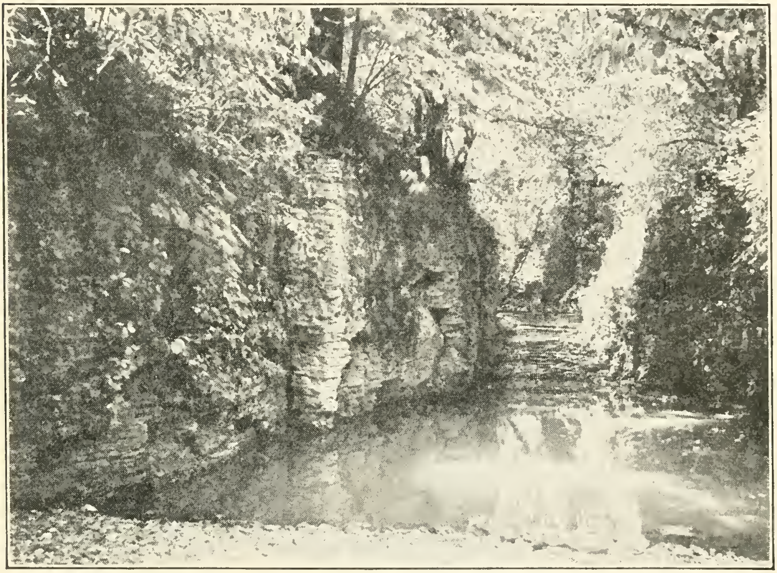


FIG. 393.—Rock ravine with vegetation on the sides, near the "Sag"

Since it is only the stream that is capable of rapid erosion in rock, the rock ravine is prone to end at its upper end in a water fall (Fig. 9). This fall gradually retreats as the stream eats its way through the rock. In relatively soft rock the fall is likely to be quite a high one, and the ravine ends abruptly. If the rock is hard, a series of rapids may replace the fall, and the ravine gradually becomes more and more shallow to its head.

It is evident that the edges of the ravine slope must be dry areas, for the soil moisture will readily drain out into the ravine. The deeper the ravine, the farther back from its edge the dry area will run. As you approach the rock ravine through the forest in the Starved Rock region there is a marked change in the vegetation, the mesophytic forms giving way to xerophytic sorts. Black oaks replace the red and white. Such shrubs as panicled dogwood, sumac, chokecherry, and ninebark, are characteristic. Patches of hairycap moss and horsetails, indicative of xerophytic conditions, appear along the edges of the ravine openings. Junipers are growing and such deciduous shrubs as the blueberry and huckleberry. These and such flowering plants as the false lily-of-the-valley and bastard toadflax found growing here are characteristic of the pine region in the Dunes.

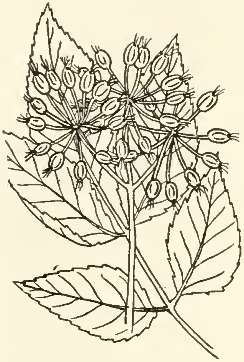


FIG. 394.—Sarsaparilla, *Aralia nudicaulis*.

The sides of the ravines support an abundant vegetation if they are sloping and have some soil. Cinnamon and interrupted ferns may grow on the banks. Where the sides are steeper still and rocky, red cedar, balsam, ninebark, gooseberry, and other plants gain precarious footings (Fig. 393); columbine, bluebells, Prenanthes, sarsaparilla (Fig. 394), shooting star occasionally, and such ferns as the fragile fern (Fig. 395) and bladder ferns (Fig. 396) are to be found growing in the cracks and crevices. In all of the ravines it is noticeable that vegetation is much more abundant on the shady side than on the side exposed to the sun. Farther down in the bottom of the ravine

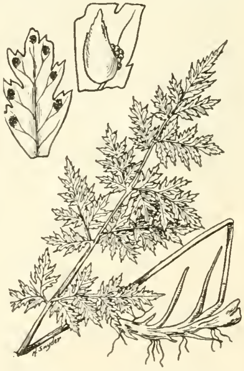


FIG. 395.—Fragile fern, *Cystopteris fragilis*.

the walls are found plastered with liverworts, *Conocephalus* being the prevalent one—*Marchantia* (Fig. 397) less common. Mosses are abundant. The purple-stemmed cliff brake (*Pellaea atropurpurea*), recognized readily by the location and its slender purple stem, is noticeable. *Selaginella* grows in beautiful masses (Fig. 398); wild hydrangea is present as an interesting shrub in the ravine bottom (Fig. 399); touch-me-not, early saxifrage, river horsetail, and other plants demanding much shade and moisture, are prevalent in the bottoms of the ravines. Bank swallows and occasionally rough-winged swallows nest on shelves of the rocks. The mourning dove, the wood peewee and ruby-throated hummingbird build on the overhanging shrubs. Snails crawl about

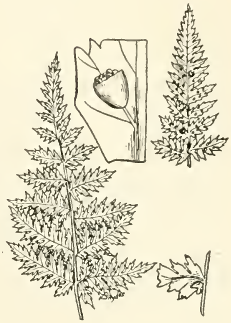
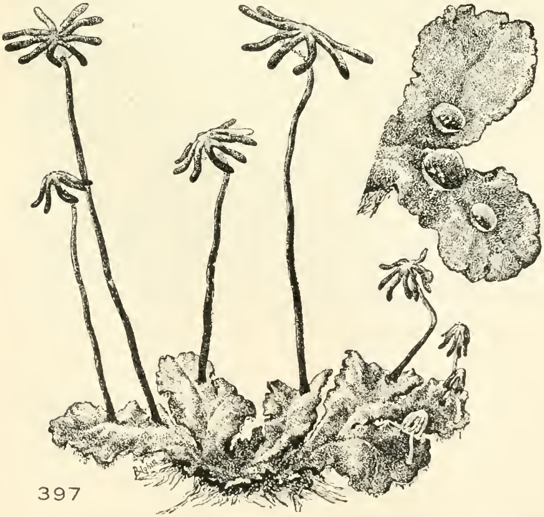


Fig. 396.—Bladder fern, *Cystopteris bulbifera*, upper right, under side of frond; upper center, one sorus.



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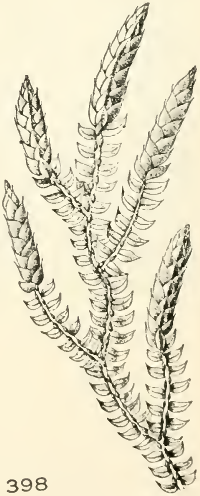

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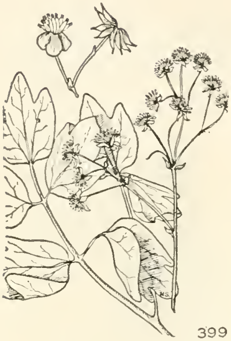
Figs. 397–398: Fig. 397.—A liverwort, *Marchantia polymorpha*, bearing archegonial branches. Upper right, portion of thallus with gemmae cups. After Atkinson; Fig. 398.—*Selaginella*. After Andrews.



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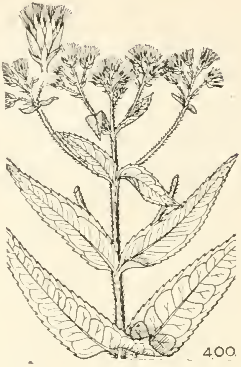

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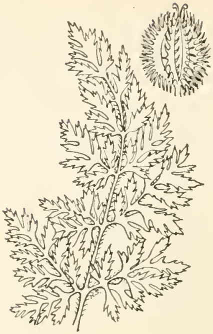

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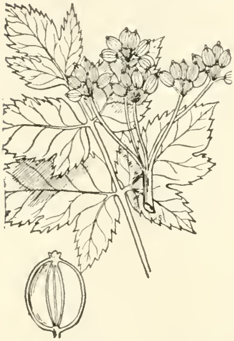

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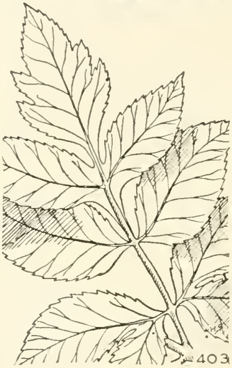

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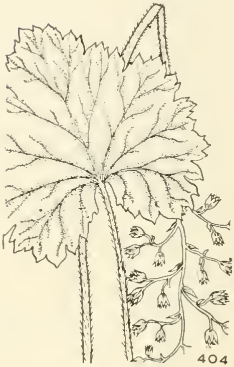

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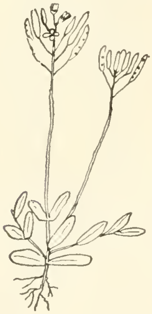

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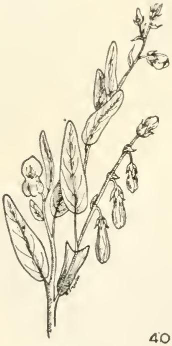

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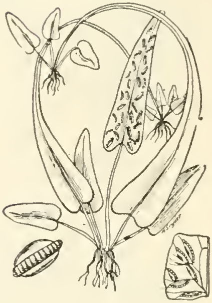

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FIGS. 399–407: Fig. 399.—Meadow rue, *Thalictrum dasycarpum;* Fig. 400.—Boneset, *Eupatorium perfoliatum;* Fig. 401.—Queen Anne's lace, *Daucus carota;* Fig. 402.—Wild parsnip, *Pastinaca sativa;* Fig. 403.—Angelica, *Angelica atropurpurea;* Fig. 404.—Alumroot, *Heuchera americana;* Fig. 405.—Whitlow grass, *Draba caroliniana;* Fig. 406.—Rattlebox, *Crotalaria sagittalis;* Fig. 407.—Walking fern, *Camptosorus rhizophyllus.*

the moist sides of the ravines. *Polygyra clausa* and *P. thyroides* are the most common in the ravines.

The clay ravine presents a slope on which the most characteristic trees are the water beech and hop hornbeam, while witch-hazel is likely to be the dominant shrub. Hepatica, bloodroot, meadow rue (Fig. 399), wood betony, Prenanthes, and maidenhair ferns are likely to be common on the lower portions of the slopes. More xerophytic forms, such as wild sarsaparilla and false Solomon's seal, are found on the upper slopes, while on the bottom, especially if a flood plain is developing,

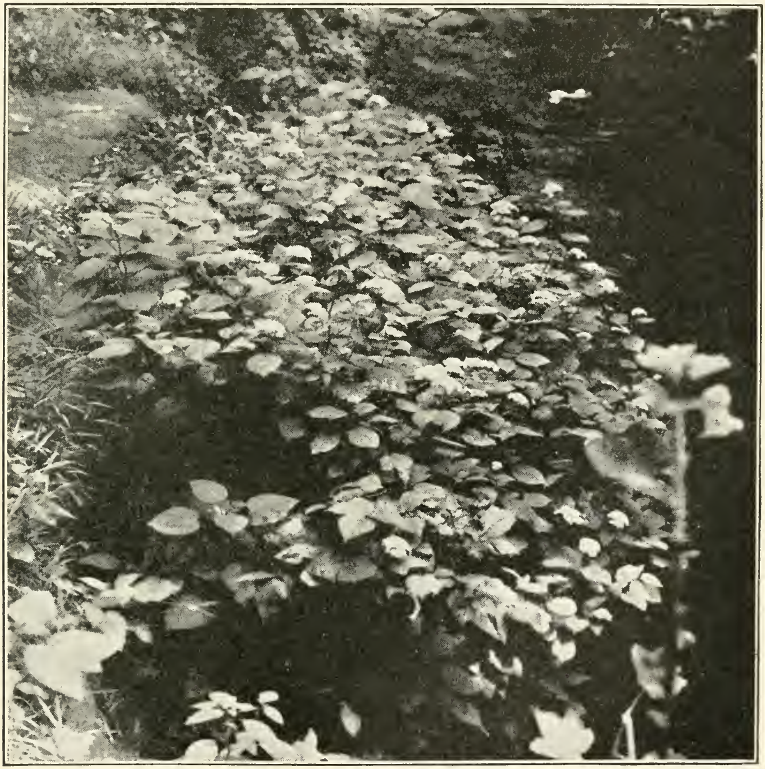


FIG. 408.—Wild hydrangea, *Hydrangea arborescens*, in French Canyon, Starved Rock.

basswood, the elms, ash, soft maple, elderberry, maple-leaf viburnum, boneset (Fig. 400), Queen Anne's lace (Fig. 401), wild parsnip (Fig. 402), and *Angelica* (Fig. 403) are likely to be present.

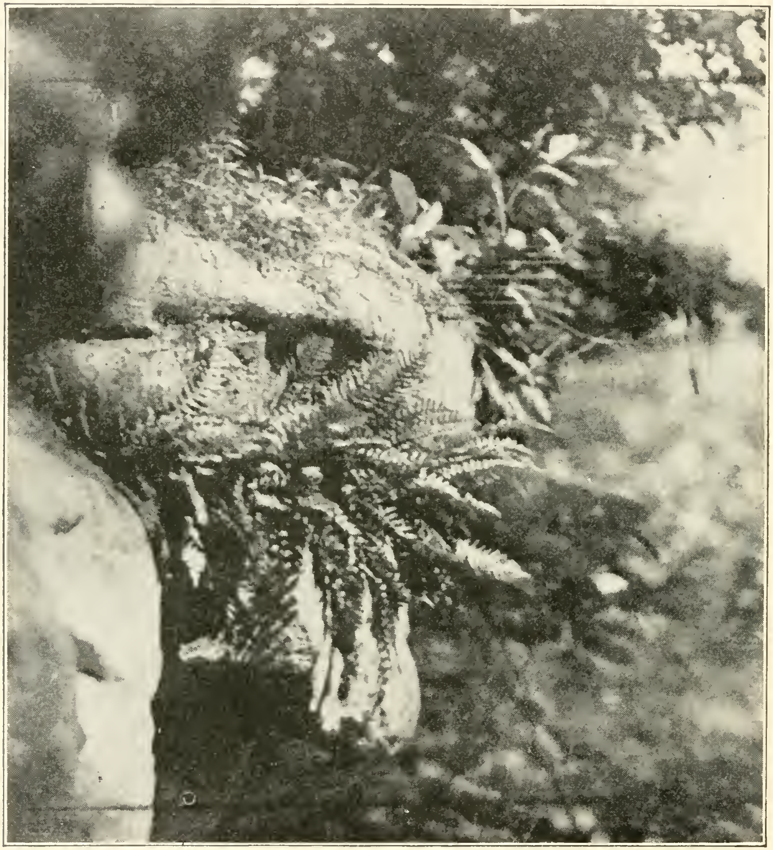


FIG. 409.—Rock polypody, *Polypodium vulgare*, on cliff at Starved Rock

Among the birds Phoebe, wood peewee, chewink, bob white, and whippoorwill are perhaps the commonest forms. The lance-head dragon fly, whose nymph is found in the pools of the stream, is very conspicuous. It is a large dragon fly with lance-shaped yellow spots along the back of the abdomen, and two conspicuous yellow bars on each side of the thorax. Snails are fairly abundant also in the lower portion of the clay ravine; the white-lipped snail, *Polygyra thyroides*, *Pyramidula alternata*, *Pyramidula solitaria*, and *Circinaria concava* are the most common ones. The green tiger beetle so characteristic of the climax forest is also abundant here.

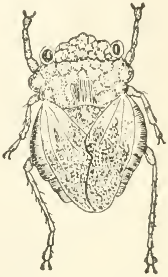


Fig. 410.—Toad bug, *Gelastocoris oculatus.*

The broad, open ravine, which develops as erosion proceeds and the sides of the steep clay ravine wear away, is so like the margin of the customary river valley that no special mention need be made of it; the description below will fit it fairly well.

The valley of the river that is cutting through rock as is the Illinois at Starved Rock, the Rock River at Oregon and Grand Detour, the Wisconsin in the neighborhood of the Dalles, is bordered by steep rock bluffs. The vegetation and animal life on these differ quite decidedly from that of the steep sides of the ravines, for the river valley is wide open to the sun's rays. Such rocky river bluffs are dry and hot. The top of the bluff (Fig. 7) has a tree and shrub population much like that of the crest of the ravine, namely, white pine, red cedar, white cedar, June berry, spreading juniper, blueberry, huckleberry, ninebark, red elderberry, etc. In the rock crevices near the top of the bluff the rock polypody fern is common (Fig. 409). The sides of such bluffs support columbine, bluebell, alumroot (Fig. 404), whitlow grass (Fig. 405), rattlebox (Fig. 406), sarsaparilla, spiderwort, Prenanthes, and occasionally walking fern (Fig. 407).

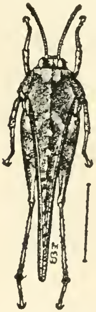


Fig. 411.—Hooded grouse locust, *Paratettix cucullatus*. After Lugger.

The steep soil slopes that lie at the base of the rocky cliffs bear a forest of black, red, and white oaks, with chokecherry, hop tree, water beech, hop hornbeam—forms which are characteristic of such slopes. Witch-hazel is the predominant shrub. The ground is covered with large areas of the cinnamon fern and, lower down, the interrupted fern.

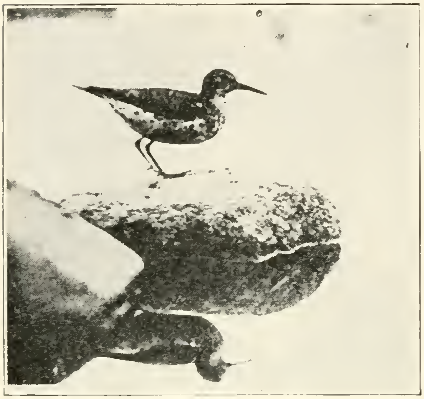


Fig. 412.—The spotted sandpiper. After Forbush.

There is an abundant bird population in these wooded slopes. Wood thrush, hermit thrush, Wilson's thrush, the ovenbird, indigo bunting, cardinal, black-billed cuckoo, crested flycatcher, and Baltimore oriole are among the commonest inhabitants. Chickadees nest in the old woodpecker holes.

On these moist slopes snails are particularly abundant. Practically all the *Polygyras* of the Chicago area are found here. *P. albolabris* and *clausa*, *fraterna*, *fraudulenta*, *hirsuta*, *inflecta*, *monodon*, *multilineata*, *oppressa*, *palliata*, *pennsylvanica*, *thyroides*, *Pyramidula alternata*, *solitaria*, *perspectiva*; *Omphalina fuliginosa*, *friabilis*; *Circinaria concava*; *Zonitoides arboreus*—these are all present. In the early morning after a shower or after a heavy dew the ground and the low vegetation is fairly alive with these numerous species. They are common in the river bottom also, and are found crawling on the paths and roadways (Figs. 284, 285).

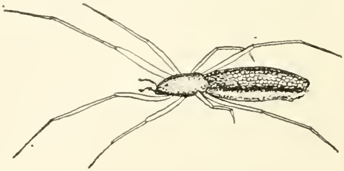


Fig. 413.—Long-bodied spider, *Tetragnatha laboriosa*.

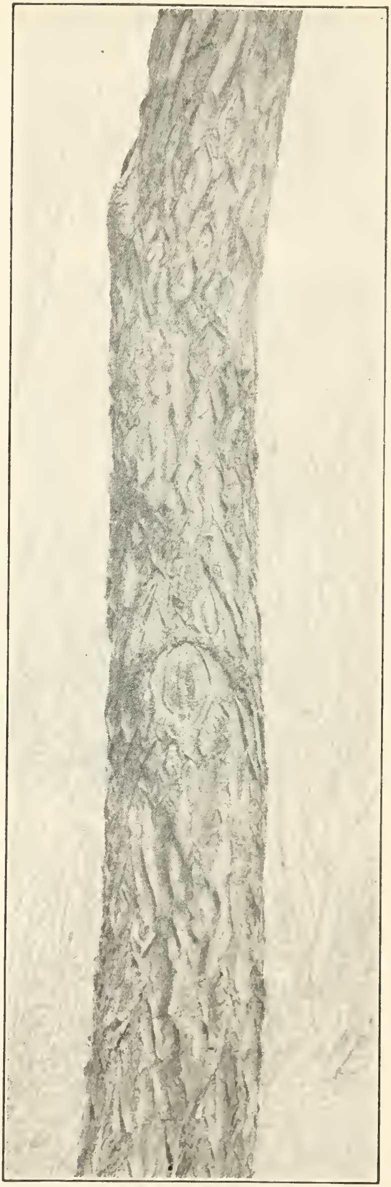


FIG. 414.—Kentucky coffee tree

The river bottom or the flood plain association is a very constant one. It is bordered by a succession of zones on its river side. First there is a zone of bare sand or gravel which is so often inundated that no plants—unless it be an occasional hardy annual weed—grow upon it. Here the toad bug (Fig. 410) is often found, the hooded grouse locust (Fig. 411), some of the same predatory ground beetles found along the lake shore, and the spotted (Fig. 412) and solitary sandpipers. All these feed on small animals washed ashore by the current. This zone, without plant life, may be designated, on its animal side, the spotted sandpiper zone.

Next comes a zone of low rich soil, inundated in the spring but which later dries out enough so it is populated by such weeds as ragweed and wild sunflower. The granulated grouse locust (Fig. 216) is found here early. Later the meadow grasshopper, *Xiphidium brevipenne,* appears. The long-bodied spider, *Tetragnatha laboriosa* (Fig. 413), finds this a favorable hunting ground. *Succinea avara* and *S. retusa* are found crawling over the wet ground or on the plants. These snails are very widely distributed in wet and marshy situations. This zone may be called the giant ragweed zone from the plant standpoint, and the *Succinea* zone on its animal side.

Then comes a zone of willows, chiefly *Salix nigra* and *S. longifolia*. The trees nearest the stream are usually small ones, the larger ones standing farther back. With these larger willows are the young white ash, elms, and soft maples that characterize the beginning of the flood plain forest proper. When these willows are in blossom in the spring there are present many flies, bees, and pollen-loving beetles like the bumble beetle. Later the conspicuous animal life is the large number of moth and butterfly larvae that feed on the willow. Mourning cloak and viceroy larvae are often found in swarms, while the larvae of *Cecropia* are usually abundant and conspicuous on account of their large size during the fall. Those of the Sweetheart and Bride are less

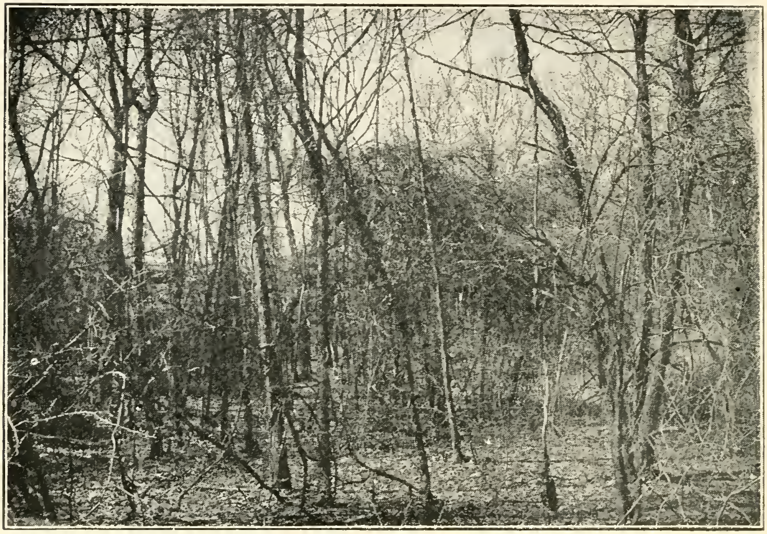
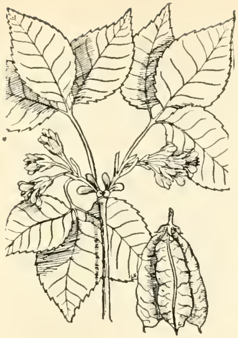


FIG. 415.—Flood plain of river with vines draped on trees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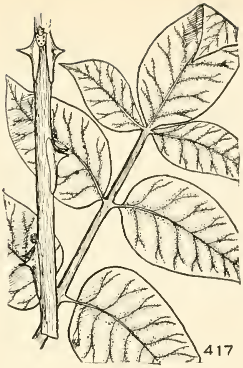
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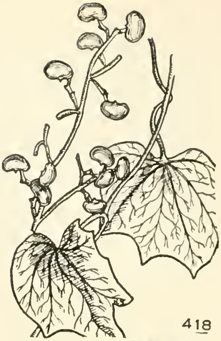
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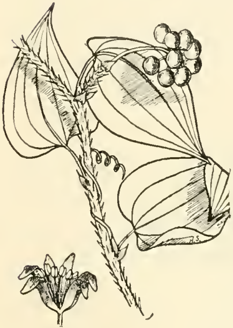
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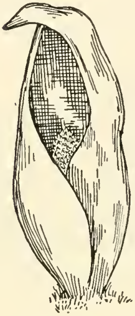
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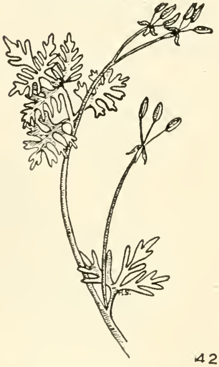
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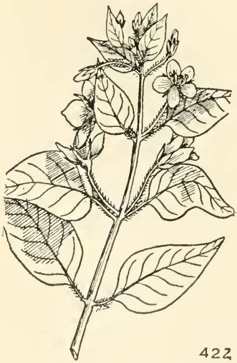
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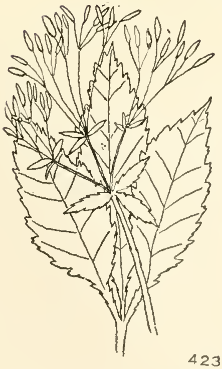
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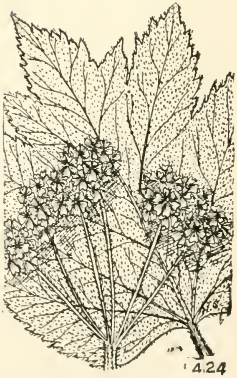
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FIGS. 416–424: Fig. 416.—Bladdernut, *Staphylea trifolia;* Fig. 417.— prickly ash, *Zanthoxylum americanum;* Fig. 418.—Moonseed, *Menispermum canadense;* Fig. 419.—Smilax, *Smilax hispida;* Fig. 420.—Skunk cabbage, *Symplocarpus foetidus;* Fig. 421.—Cheveril, *Chaerophyllum procumbens;* Fig. 422.—Fringed loosestrife, *Steironema ciliatum;* Fig. 423.—Honewort, *Cryptotaenia canadensis;* Fig. 424.—Cow parsnip, *Hieracleum lanatum.*

conspicuous. This zone is very evidently the willow zone on its plant side and may be designated the cecropia larva zone on its animal side.

Farther back from the stream is the flood-plain forest proper. Red and white elms, white and black and blue ash, basswood, soft maple, hackberry, black cherry, black walnut, sycamore, and black willow are the common trees, with white elm, white ash, and soft maple dominant members of the association. In addition, the Kentucky coffee tree, *Gymnocladus dioica* (Fig. 414), is common a little farther south, and when one gets away from the lake in the Chicago area, the tulip tree, pawpaw, flowering dogwood, and redbud are often found in the river-bottom association. Of the smaller trees the hawthorn, American crab, chokecherry, and the hop tree are conspicuous. The shrubs that are characteristic are buttonbush, burning bush, or wahoo, elderberry, bladder nut (Fig. 416), nannyberry, prickly ash (Fig. 417), and in some places the strawberry bush covers large areas of the ground.

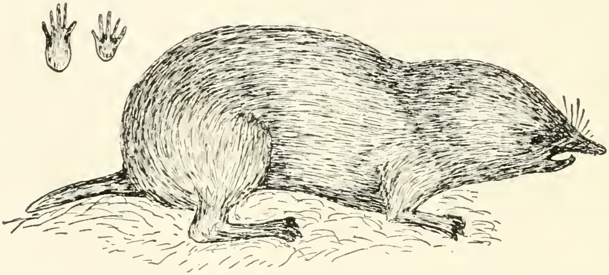


FIG. 425.—Short-tailed shrew, *Blarina brevicaudata*, and footprints

The river bottom association is characterized by many woody vines, some of which climb up the low trees and drape them with dense festoons (Fig. 415). Such are the Virginia creeper, poison ivy, bittersweet, honeysuckle, moonseed (Fig. 418), and the wolf grape. Several species of smilax are also common (Fig. 419).

As in the climax forest there is present here an abundance of spring herbs that bear blossoms and set their fruit before the dense shade of summer is produced by the thick foliage of the trees and shrubs. Skunk cabbage (Fig. 420) and marsh marigold come early in the wet areas. Spring beauty often covers the ground completely, and later the phlox (*Phlox divaricata*) may cover acres with its bloom. Bloodroot, bedstraw, cheveril (Fig. 421), blue cohosh, dogtooth violet, fringed loosestrife (Fig. 422), geranium, wild ginger, honewort (Fig. 423), leeks and onions, false mermaid weed, cow parsnip (Fig. 424), Solomon's seal, both true and false, sweet cicely, spring cress of several species (Fig. 362), trillium, toothwort (Fig. 55), violets, and waterleaf are the common members.

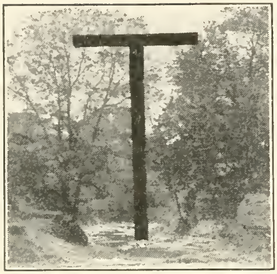
It is interesting to note the arrangement of these flood-plain zones on an island in midstream. Some shift of current or some obstruction causes the sediment held by the river to deposit, and so a mud barrier forms in midstream, a patch of flood plain disconnected from the shore. Such an island grows on its downstream side because the current is checked by the obstruction and the deposit is in the quiet waters below it. Vegetation, therefore, appears on its upper end as soon as this portion dries out sufficiently to permit plant growth. For the same reason, the flood plain forest develops here, and successive zones extend toward the lower end. Islands in a lake or pond have their zones arranged more or less in concentric rings in contrast to the longitudinal zones of the river island.

There is usually a marked contrast between the vegetation of the river valley and that of the bordering hills. We have already noted above the vegetation of the rock hills. Customarily the hills that border the flood plain bear the usual white oak, red oak-hickory forest, which has been considered in chapter x.

In most respects the animal life of the flood-plain forest is very like that of the climax beech-maple forest, though the forms are not as numerous, as the annual inundation prevents the permanent residence of many animals. The short-tailed shrew (Fig. 425), white-footed deer mouse (Fig. 287), and common mole (Fig. 286) are usually present. The same beetles are present on the ground and in the rotting logs. The mollusks are similar though not as numerous.

CHAPTER XIII

BROOK, CREEK, AND RIVER



THERE are a number of factors influencing the character of the animal and plant life of the stream, though most of them act as indirect determiners affecting the quantity and character of the gases contained in the water, its acidity or alkalinity, the temperature or rate of flow of the stream, which are the principal immediate causes of variation in the stream fauna and flora.

If the sources of the water supply are such that the stream flows intermittently, drying up to form a succession of stagnant pools when the rains cease—usually in midsummer—but running as a brook or creek during the spring freshets or the fall rains, the life it contains will be quite different from that of the steadily flowing streams. A spring-fed brook, because of its low temperature, will support a population quite unlike that of the stream that emanates from pond or swamp. A stream whose waters are distinctly acid from abundant decomposing organic matter or from factory waste will have quite a different fauna and flora from the usual alkaline stream of this area. The population of the Illinois River has suffered very marked change in recent years because of the increase in decomposing organic matter brought to it by the Chicago Drainage Canal. Thorn Creek has largely lost its normal inhabitants on account of factory waste, and a new set of organisms have come in.

The stream from source to mouth shows a succession of species, those of the small brook giving place to others that appear as the stream widens and deepens. So we may speak of the headwaters or brook society, the midcourse or creek society, the lower stream or river society, and finally the estuary society, found in the sluggish, backed-up waters near the mouths of some streams. The inflowing streams, tributaries to the main river, are likely to display quite unlike inhabitants, those entering well down toward the mouth showing marked contrasts to those entering up toward the source, for the animals and plants present in the main stream, whence they migrate into the tributaries, are so different in the various parts of the course.

Even in the same region of the stream the species present will vary according to varying depth and rapidity of the current. Along shore the water is shallow and so relatively well aerated, while in the deeper portions of the stream the volume below a given area of surface is much greater and the concentration of carbon dioxide and other gases of decomposition is higher, other things being equal. So a zonation of plants and animals from shore outward may be expected. For the same reason there is a zonation from the surface downward since the oxygen content of the surface layers is high as compared with the bottom layers. This evidently will be most marked in the quiet stretches. In the rapids where the water is constantly stirred from top to bottom there will be no such marked difference. So in the sluggish stretches of the river the oxygen content will be low, that of carbon dioxide high, while in the rapids where the water is well aerated by its turmoil the reverse will be true. Active forms demanding much oxygen can live in the latter situations but not in the former.

The character of the bottom affects the animal and plant population. As a rule the stream has its bottom covered with rocks or coarse gravel in its most rapid stretches, a sandy bottom where it is less rapid but still flowing quite vigorously, and a mud bottom in its quiet stretches. In part, the differences in plant and animal life on these different bottoms are due to the varying rates of the current, but in part they are directly connected with the character of the bottom itself. Some plants and animals, for instance, are adapted by holdfasts to attach themselves to a rock substratum, others burrow only in sand, and still others require the soft mud in which to lie concealed.

It is evident, then, that streams present a great variety of habitats and, therefore, a number of animal and plant societies, which may be tabulated somewhat as follows:

A. Communities of the intermittent stream
    1. Intermittent rapids society or the *Simulium* (black fly) association
    2. Intermittent pool society or the *Cambarus diogenes* association
    3. Permanent pool society or the horned dace association

B. Communities of permanent streams
    4. The spring-fed brook or planarian association
        a) Of the usual alkaline stream
    5. The very rapid water (lotic) society or the *Hydropsyche* association

        This is a rock-bottom society and may be subdivided into
        a) Rapids of the brook, Johnny darter association
        b) Rapids of the creek, fan-tail darter association
        c) Rapids of the river, banded darter association
    6. The moderately rapid, sand-bottom society
        a) Of the brook
        b) Of the creek
        c) Of the river
    7. The sluggish water surface association
    8. The sluggish water bottom association
        } both divisible as the foregoing into *a*), *b*), *c*)
    9. The estuary associations
    10. The acid stream society

It would require a volume rather than a chapter to discuss in detail the stream societies and subsocieties with anything like thoroughness. We must be content, therefore, to indicate briefly changes in animal and plant population as the stream grows in size from brook to creek and to river. Then attention may be called to the societies of rapid water as contrasted with those of sluggish water, and finally we may take up very briefly the societies of intermittent streams, of spring-fed streams, and of acid streams.

Take first the distribution of some of the river clams in the Illinois River and its branches. The data are taken largely from Baker's "Catalogue of the Mollusca of Illinois," *Bulletin of the Illinois State Laboratory of Natural History*, Volume VII, Article VI, and his "Mollusca of the Chicago Area," Part I, "The Pelecypoda," *Publication of the Chicago Academy of Sciences*. The larger branches of the Illinois from its mouth toward its source are in order, (1) the Sangamon, (2) the Spoon, (3) the Mackinaw, (4) the Vermillion, (5) the Fox, (6) the Kankakee, (7) the Desplaines. It is the union of the last two that makes the Illinois. The more important branches of the Desplaines are (8) the DuPage, (9) Hickory Creek, (10) Salt Creek. The smaller creeks or runs are mere brooks and do not support a clam population. Of the genus *Lampsilis* only two get up into Salt Creek, namely, *L. luteolus* and *L. ellipsiformis*. Four more are found in Hickory Creek, *L. ventricosa*, *L. fallaciosa*, *L. iris*, and *L. parva*. All of the foregoing except one, *L. fallaciosa*, are reported from DuPage River, and in addition four others, *L. ligamentina*, *L. anadontoides*, *L. recta*, and *L. alata*. All of the foregoing are found in the Illinois and its larger branches, and in addition six other species that do not get up into the Desplaines.

Anadonta marginata is found in Hickory Creek but not in Salt Creek. *A. grandis* and *A. grandis footiana* are in the DuPage but not farther north. *A. imbecilis* is in the Desplaines but not in its branches. The Quadrulas are almost entirely confined to the larger streams. *Q. rubiginosa* is reported from Salt Creek and *Q. coccinea* from the DuPage. There are eighteen other species in the Illinois and its larger branches named above.

Consider next the dragon-fly nymphs. I quote from Needham's "Dragon-Flies of Illinois," *Bulletin of the Illinois State Laboratory of Natural History*, Volume VI, Article I. This indicates not only that the distribution depends on the size of the stream but also that forms vary according to the rapidity of the current and the character of the bottom.

> In the larger rivers, down to the size of the Mackinaw, in places where the water flows with considerable current over a rocky bottom, *Diastatomma* may be looked for; where mud or sand bottom and quieter waters prevail, *Epicordulia* and some species of *Gomphus* may be found. Other species of *Gomphus* occur in the bare muddy or sandy bottoms of the sloughs and bottom-land lakes. In tree shaded waters, where driftwood and branches have gathered, or along muddy margins, especially among exposed roots, the lower *Aeschnidae* may be looked for. In bottom-land lakes where vegetation is abundant, one may find *Anax*, *Agrionidae*, *Mesothemis*, *Celethemis*, *Tramea* and *Pantala* amongst the vegetation, the latter two especially on more exposed shores; and *Tetragoneuria*, *Libellula*, *Epicordulia* and *Leucorhinia* on the bottom underneath. If the situation is inclined to be marshy, *Pachydiplax*, *Perithemis* and *Celithemis* will be scattered over the bottom; and the shallowest and most temporary waters or wet lands are the especial home of *Sympetrum*.
>
> In the smaller and quicker flowing streams, like the upper Mackinaw and Sangamon, quite a different series occurs: *Hagenius* clinging to stones and driftwood and amongst dead leaves; *Boyeria* and other dark *Aeschnidae* on submerged branches, roots and sticks; *Cordulegaster* and the long-legged *Macromia* hidden at the bottom in sheltered eddies; *Somatochlora*; and finally *Progomphus*, *Dromogomphus* and certain species of *Gomphus* burrowing in the sandy bottom. In the prairie ponds and slow streams and ditches, *Anax*, *Agrionidae*, and *Mesothemis* and other *Libellulidae* occur amongst vegetation, and *Sympetrium* in shallower parts, while *Libellula* and *Plathemis* will be found where there is more mud and less vegetation, as in ditches and tile ponds, resting at the lower ends of well defined tracks. In streams of rapid flow but not especially rocky or shaded, the *Calopterygidae* are most likely to be found, the imagoes fluttering along the banks.

Of the above-mentioned the *Agrionidae* and the *Calopterygidae* are families of the damsel flies whose nymphs bear three leaflike tracheal gills at the posterior end of the abdomen. The basal segment of the antennae is nearly round in the former, very elongate in the latter. The rest are included in four families of the dragon flies. The *Aeschnidae* and *Gomphidae* have a flat mask that does not cover the face. The former have six- or seven-jointed slender antennae; the latter, four-jointed stout antennae. The *Cordulegasteridae* and the *Libellulidae* have a mask that is spoon-shaped and that covers the face. The teeth on its opposing edges in the former are large, acute, and interlocking; in the latter they are rounded. Family *Aeschnidae* includes of those mentioned above, *Anax*, *Aeschna*, and *Boyeria*, the nymphs of which have respectively three, four, and five pairs of lateral spines on the sides of the abdomen (Fig. 426). Family *Gomphidae* includes *Progomphus*, *Diastatomma*, *Hagenius*, *Dromogomphus*, and *Gomphus*. In *Progomphus* the middle pair of legs are set closer to each other than are the forelegs, in the others at least as far apart as the forelegs, in *Hagenius* farther apart. *Hagenius* also has more than four pair of lateral spines, the others not over four pair. The tenth or last abdominal segment of *Diastatomma* narrows posteriorly, while that of

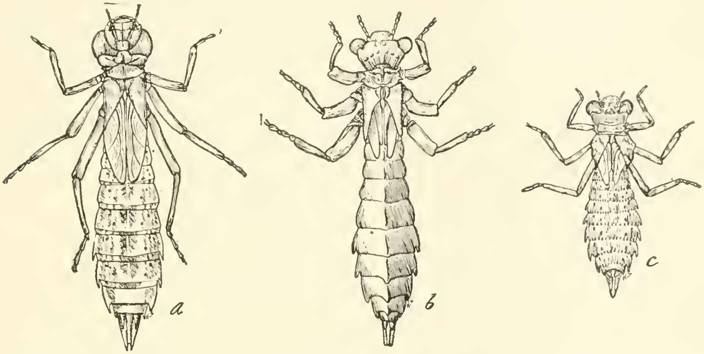


FIG. 426.—Nymphs of the dragon flies: *a*, *Anax;* *b*, *Aeschna;* *c*, *Boyeria*. After Needham.

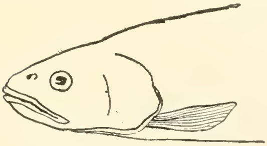


FIG. 427.—Head of horned dace, *Semotilus atromaculatus*.

Dromogomphus and *Gomphus* has its sides parallel. Of the two latter the first has acute, spiny-tipped dorsal hooks on the abdominal segments, while in *Gomphus* such hooks are usually absent and are always dull. Family *Cordulegasteridae* includes only the genus *Cordulegaster.* The rest are therefore included in family *Libellulidae,* the nymphs of some of which are not sufficiently well known to make accurate determination possible. If there is a pyramidal horn on the front of the head and a small dorsal hook on segment ten, the nymph is of the genus *Macromia.* If the head bears a tubercle on each side and segments three to nine bear dorsal hooks, the nymph is that of *Epicordulia.* If the lateral

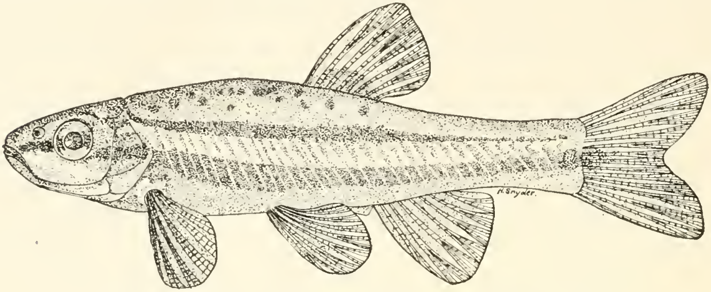


Fig. 428.—Red-bellied dace, *Chrosomus erythrogaster*

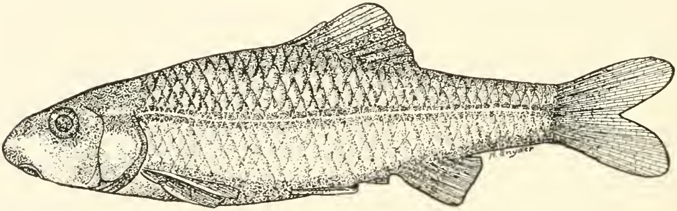


Fig. 429.—Blunt-nosed minnow, *Pimephales notatus*

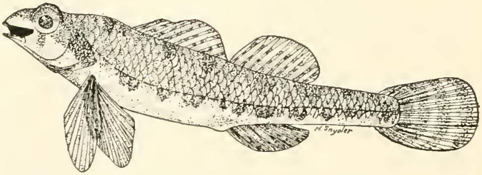


Fig. 430.—Johnny darter, *Boleosoma nigrum*

spines of segment nine are sharp, divergent, and longer than the appendages of segment ten, it is a nymph of *Tetragoneuria;* while if the spines of nine are incurved and not longer than the appendages of ten, the nymph is that of *Somatochlora.*

If the fish of the streams are studied, again we find certain species in the headwaters, others coming in down in the mid-course, still others not appearing until the river stage is reached, and finally some largely confined to the estuary. Streams that are mere brooks, short and small, will have the same sort of fish that are found near the headwaters of the larger rivers. The horned dace (Fig. 427) is apparently the fish that works its way farthest upstream, often living in the pools of brooks that otherwise have dried up. The red-bellied dace (Fig. 428) and the black-nosed dace are not far behind it. The blunt-nosed minnow (Fig. 429), Johnny darter (Fig. 430), and the rainbow darter

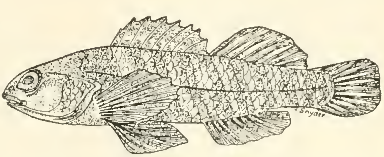


FIG. 431.—Rainbow darter, *Etheostoma coeruleum*, two-thirds natural size.

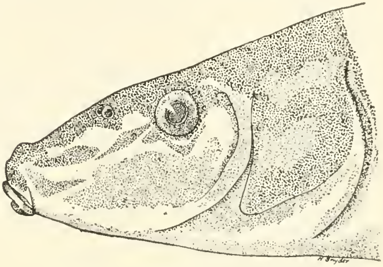


FIG. 432.—Head of common sucker, *Catostomus commersonii*, one-third natural size.

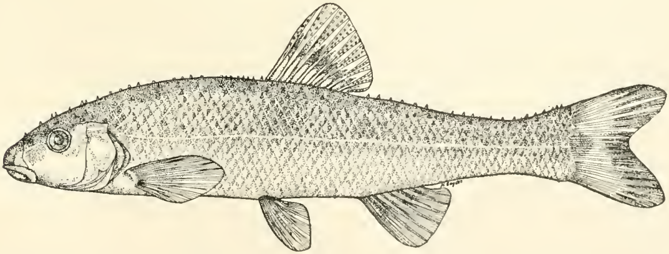


FIG. 433.—Stone roller, *Campostoma anomalum*

(Fig. 431) are also inhabitants of the smaller brooks, while the golden shiner, the common sucker (Fig. 432), and the chub sucker (Fig. 192) also get well up stream.

The following may be considered primarily creek fish: the black bullhead, red horse, stone roller (Fig. 433), common shiner, river chub, common top minnow, *Fundulus dispar* (Fig. 434), fantailed darter (Fig. 440). While those that are found in the rivers are the mud cat, the stone cat, banded darter, hog-nosed sucker (Fig. 435), straw-colored minnow (Fig. 436), redfin, red-faced minnow, gizzard shad, mud minnow, brook silversides, rock bass (Fig. 437), small-mouthed black bass, black and white crappies (Fig. 438), the last four especially in the gravel-bottomed pools. In the estuary are to be found those fish that are ordinarily lake-inhabiting forms such as the dogfish, tadpole cat, buffalo, grass pike, bluegill, pumpkin-seed, large-mouthed black bass, pike perch, and yellow perch. This is, of course, not to be interpreted as meaning that the brook fish, the creek fish, or the others are confined to one particular habitat, but merely that if one makes systematic collections they will be captured most frequently in the situations indicated.

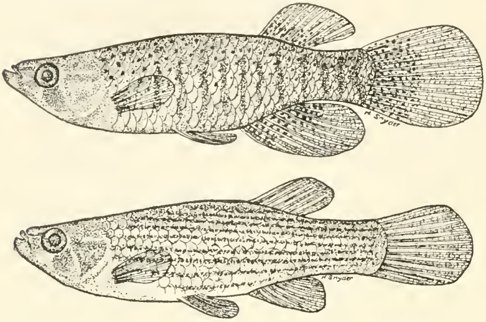


FIG. 434.—Top minnow, *Fundulus dispar*, male and female.

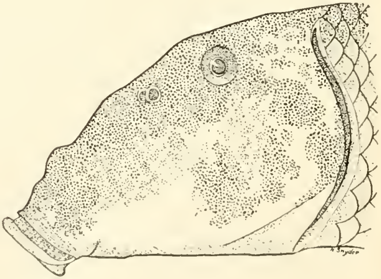


FIG. 435.—Head of hog sucker, *Catostomus nigricans*, one-half natural size.

That portion of the stream where rapid water hurries over stony bottom is the habitat of the darters, the sucker-mouthed minnow (Fig. 439), the stone roller, the hammerhead sucker. The rainbow darter, the fantail, black-sided (Fig. 441), sharp-

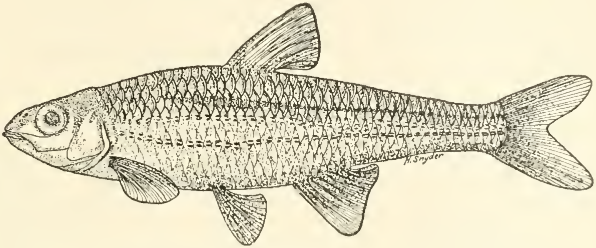


FIG. 436.—Straw-colored minnow, *Notropis blennius*

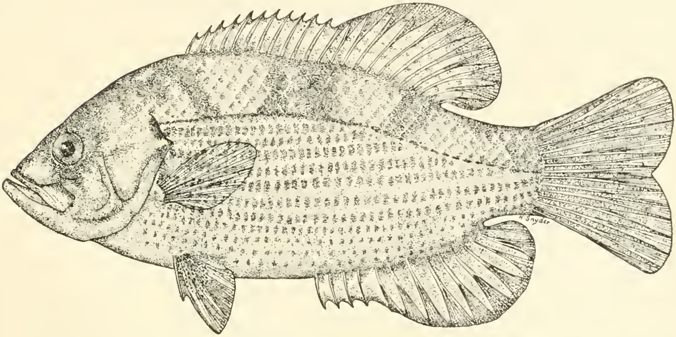


FIG. 437.—Rock bass, *Ambloplites rupestris*, one-half natural size

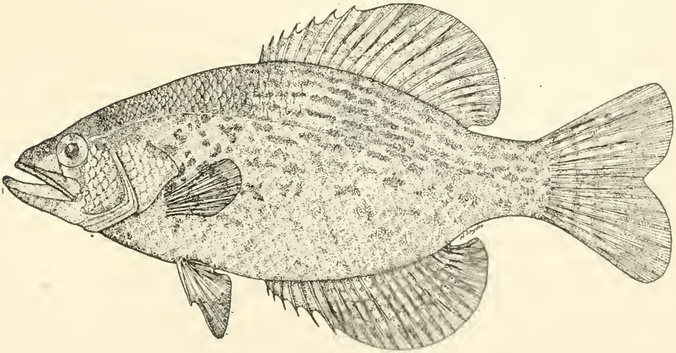


FIG. 438.—Black crappie, *Pomoxis sparoides*, one-third natural size

headed (Fig. 442), banded, and Johnny darter are all able by their large pectoral and anal fins to hold themselves among the stones in the swift current and search under them with their pointed heads for insect larvae. The sucker-mouthed minnow has similar feeding habits. The stone roller, as the name indicates, moves the smaller stones in his efforts to nibble off the slime, while the hammerhead sucker can dislodge quite good-sized stones in his effort to locate hiding animals. On the other hand, there are certain fish found in the sluggish waters over mud bottom. Such are the black bullhead, hog sucker, and golden shiner.

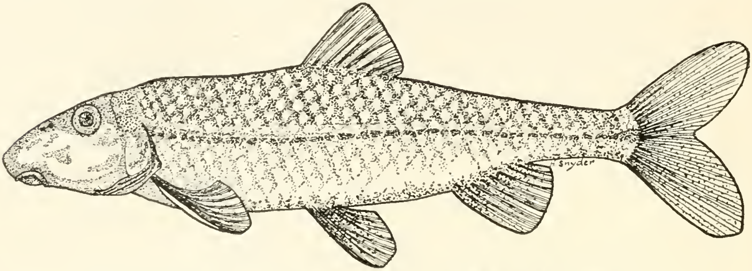


FIG. 439.—Sucker-mouthed minnow, *Phenacobius mirabilis*

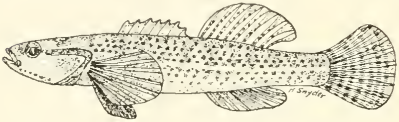


FIG. 440.—Fan-tailed darter, *Etheostoma flabellare*, two-thirds natural size.

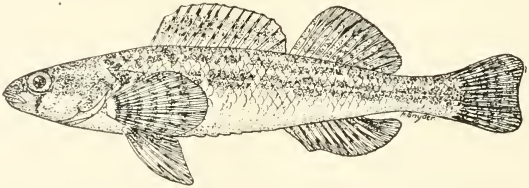


FIG. 441.—Black-sided darter, *Hadropterus aspro*

No association contains more remarkably adapted animals than this lotic or *Hydropsyche* association. The net building caddis fly (*Hydropsyche*) (Fig. 443) forms a cornucopia-shaped tube open at both ends with the large flaring end upstream, This is attached to the rocks on the bottom. The large end of the tube is covered with a cup-shaped net spun of silken strands. The larva lies at one side of the net and picks off the small animals and plants the current brings down. Not infrequently the entire upper surface of the stones on the bottom will be covered with these net tubes of this larva. Another caddis-fly larva, *Helicopsyche*, has a coiled tube built of sand grains (Fig. 444) that appears like a small snail shell. This lives in moderately rapid water of the large creeks where the bottom is pebbly. It attaches to the rocks. The larva of the black fly, *Simulium*, is universally present in the rapid water running over stones from the merest trickle in the tiny runnel way down stream as long as rocks on the bottom afford attachment. The larvae appear like black, squirming, short worms with brushes of bristles at the free end, by means of which they catch the tiny animals and plants floating in the current. They are so numerous as to make great patches on the rocks. Each larva is attached at one end by a sucker but can let go at will when it spins a silken strand, at the end of which it dangles in the water, seeking new feeding ground. The adults are the pestiferous tiny flies that swarm about the head of the fishermen or the udder of browsing cattle and take bloody toll. Under the stones one finds bloodworms, larvae of midges of genus *Chironomus*, stone-fly nymphs (*Perla*), damsel-fly nymphs (*Argiaputrida*), May-fly nymphs (*Siphlurus alternatus*), the larva of a water beetle (Fig. 446) so flattened and rounded it is called the water penny (*Psephenus lecontei*). These nymphs in the rapidly running water have head, body, and limbs all flattened to offer the least possible

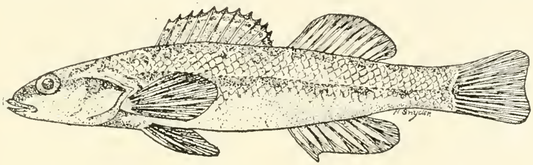
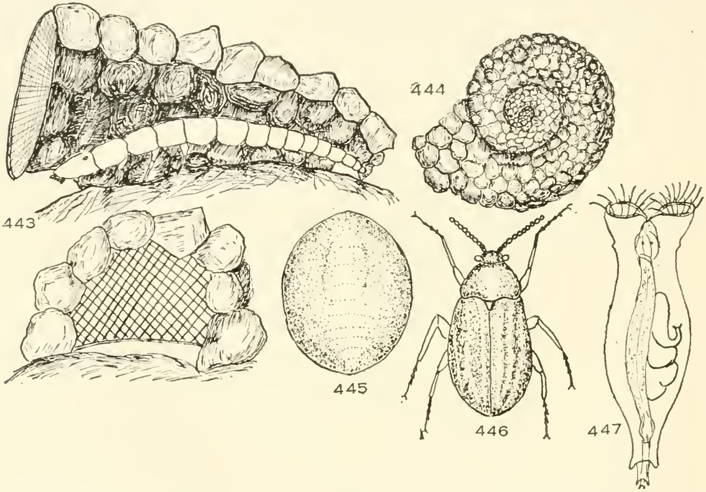


FIG. 442.—Sharp-headed darter, *Hadropterus phoxocephalus*

resistance to the water, and many of them have specially developed suckers, by means of which they attach to the rock. The water penny (Fig. 445) is so altered by its adaptation to its environment that one would never take it at first sight for a beetle larva.

The snail, *Goniobasis livescens*, lives in the rocky rapids, dozens of them often on a single bowlder, clinging on by their strong muscular foot, feeding on the microscopic plants that form the slimy layer of green scum on the rocks. The liberty cap snail, *Ancylus*, whose coiled shell has been reduced to a broad, low cone, is fairly abundant in the stony rapids of the brooks.



FIGS. 443–447: Fig. 443.—Net-building caddis-fly larva, *Hydropsyche*, in its tube (above); front view of tube (below), enlarged; Fig. 444.—Coiled tube of larva of caddis-fly, *Helicopsyche*, enlarged; Fig. 445.—Water penny, larva of 446; Fig. 446.—Brook beetle, *Psephenus lecontei;* Fig. 447.—A common rotifer, much enlarged.

Pleurocera elevatum is found where the current is not so very strong. It often prefers the gravelly margins of the stream. The crayfish, *Cambarus virilis*, is found hiding under the stones, very commonly.

In the moderately rapid waters with sandy or gravelly bottom will be found *Campeloma subsolidum* and *C. integrum*, good-sized snails. These spots are the habitat of the clams already mentioned. It is in the larger rivers that the good-sized specie occur abundantly, forming mussel beds on the sand bars. The clam lies buried in the sand or silt with only the posterior portion of the shell protruding. Out of this end stick the siphon tubes which take in the water containing the tiny animals and plants (plancton) on which the clam feeds. It is from the thick shells of the larger species that the pearl buttons are stamped.

In the quieter stretches of the stream, where the bottom is muddy, will be found the burrowing May-fly nymphs of genus *Hexagenia*, the fish and dragon-fly nymphs already noted, and a number of forms identical with those of ponds. Just at the margin of the quiet waters, where the current goes swiftly by, will be found the May-fly nymph, *Chirotenetes siccus*.

The plant life along the shore and in the bed of the stream is in general appearance very like that in similar situations in the ponds and lakes, though the constituent species may be quite different. Attached to the rocks and logs in the stream bed are numerous filamentous algae and some water mosses. Stones and logs are found, slippery with the mucus secreted by diatoms or other algae that coat their surfaces with a dense layer of plant life, and the stream is often choked in its quieter stretches with submerged plants similar to those of the ponds, *Myriophylum*, *Utricularia*, *Elodea*, *Vallisneria*, *Ceratophyllum*, etc. In quiet stretches pond lilies are common. The shores are lined with zones of plants, rushes, cat-tails, arrow root, sedges, and grasses.

These relatively quiet marginal areas are the breeding-places for an abundant plant and animal life, largely minute forms, the overflow of which is carried downstream in the current as the plancton. This consists largely of microscopic plants, diatoms, desmids, and other single-celled forms, of some filamentous types, of many animals like the protozoa, rotifers (Fig. 447), and small crustaceans. The waters of midstream are teeming with this floating population, of which one is not aware until he strains it out with a fine net. Kofoid found in the Illinois River at Urbana almost five million organisms to the quart, a million of which were animals. He estimates the total plancton carried down by the river per year at more than two and one quarter million cubic feet of solid organisms. Certain flagellates, ciliated forms like Vorticella, and the shell-bearing rhizopods, *Difflugia* and *Arcella*, are among the commoner protozoa. *Daphne*, *Bosmina*, *Acroperus*, *Leptobora*, are common cladoceran crustaceans, while *Cyclops*, *Diapotamus*, and *Canthocampus* are the customary copepods. A very transparent midge larva, *Corethra*, is sometimes very abundant. It is nearly an inch long and so transparent that the internal organs are plainly visible as if it were made of glass. The crustaceans of the plancton are the staple article of diet for all of the small

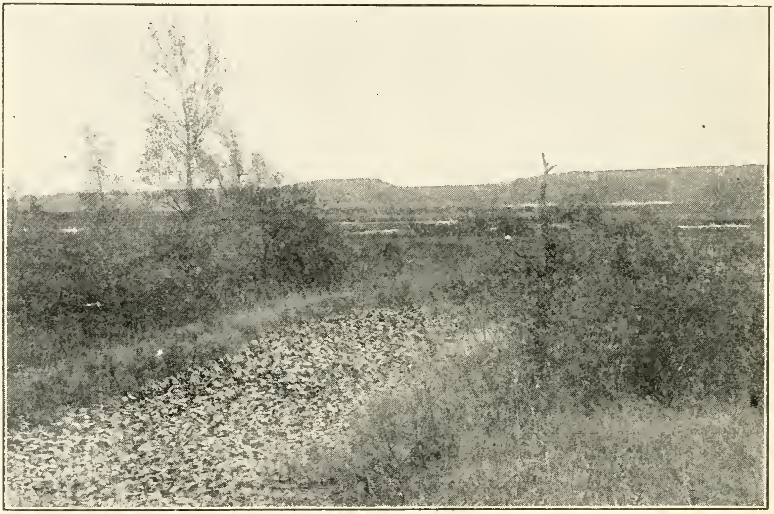


FIG. 448.—Valley of lower Galien River, New Buffalo, Michigan. Note plant zonation in foreground.

carnivorous fish of the stream. The crustaceans, in turn, feed upon the smaller organisms of the plancton, both plant and animal.

The first animal to appear in intermittent streams, even when it is a mere trickle, is the larva of the black fly. Along with this are to be found larvae of May flies, under the stones, and caddis worms in their irregular tubes formed of bits of stone (*Rhyncophilidae*).

In the pools of such intermittent streams are found in the spring crayfish (*Cambarus diogenes*) that dig in and live in their burrows as the temporary pools dry out. They come out at night to secure their food. As the pools become larger and more permanent, *Cambarus virilis* and *C. propinquus* replace the burrowing crayfish. *Gammarus fasciatus* and *Asellus* are added to the crustacean population. Water striders, back-swimmers, and water boatmen appear. The diving beetles, *Hydroporus* and *Agabus*, are found. Burrowing dragon-fly nymphs inhabit the pools, and the adults fly over their surfaces (*Aeschna constricta* and *Cordulegaster obliquus*).

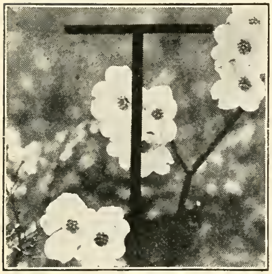
The first fish to appear is the horned dace (*Semotilus atromaculatus*). It swims away upstream to deposit its eggs, so the young are common in these temporary pools and often die in large numbers as they dry out. The red-bellied dace (*Chrosomus erythrogaster*) is likely to get almost as far upstream, but breeds only in pebbly and sandy bottom. It, too, is found in the temporary pools.

In the spring-fed brooks the characteristic vegetation is the water cress. Black-fly larvae are present, as also the same benders, crayfishes and beetles mentioned above. In addition, the net-building caddis fly (*Hydropsyche*) is found. The brook beetle, *Elmis fastiditus*, is very characteristic. The spring-fed brooks in our locality are very short, usually joining some larger stream quite promptly. In these springs and brooks such planarians as *Dendrocoelum* and *Planaria dorotocephala* are abundant.

As one proceeds downstream to a point where the river has cut down nearly to the level of the body of water into which it flows it is prone to become sluggish, choke its own mouth with sand or mud bars, back up and spread out over a wide area of its lower flood plain, and so develop an estuary. A very good example of this is seen above the mouth of the Galien River at New Buffalo, Michigan (Fig. 448). Conditions are practically those of the filling lake or pond. The zones of plants and animals are well developed and occur in the same order as already discussed in the chapter on the filling pond.

CHAPTER XIV

SOME SOURCES OF OUR FAUNA AND FLORA



THE preceding chapters, if they have accomplished their purpose, have given the attentive reader the conception, based on a good deal of detailed evidence, that plants and animals are not jumbled together in the outdoors in chance assortments, but are grouped in very definite associations, quite as clear cut as are human societies. Indeed, sociology may be regarded as the science of human ecology. This notion gives added zest to one's excursions afield. You learn not only to recognize the common-place forms but to study their groupings and to give attention to those structural and functional adaptations by which organisms are fitted to a specific environment. We have found structurally very unlike forms, both plant and animal, closely associated, and very like forms completely separated. The rapids society of the stream is made up of fish, insect larvae of many orders, crustaceans, leeches, and mollusks, a strangely assorted family. On the dunes the closely related tiger beetles, all predatory forms very similar in habit, were found each in its particular zone. Ecological groupings of plants and animals will often or usually cut across taxonomic groupings.

Thus far, however, we have considered the matter from the static point of view. We have considered the associations of plants and animals as they are. There is a dynamic side. We need to consider how they have come to be. The present is the outcome of an eventful past and is to be explained as the resultant of many forces operating through long periods of time.

Without going back unduly into the past, it is very evident that when the last glacial advance slowly came on and buried the Great Lakes region almost in its entirety under thousands of feet of ice, the plant and animal life existent here before the advance began must have been obliterated, except in so far as it could retreat southward into congenial territory. Moreover, there must have been a complete change in the fauna and flora even before the glacier arrived. For as it progressed there preceded it a change in climate. The rigors of the winters increased, the summers became brief and cool. Many of the plants and animals flourishing here before the ice sheet began its southward movement must have been driven out and replaced with forms more characteristic of the north. Evergreens took the place of the deciduous forests, and the animals changed accordingly. As the glacier approached still nearer, the coniferous forests extended farther south, while here trees were becoming dwarfed. Then this region became treeless, and tundras covered with hardy grasses, mosses, and lichens occupied it, similar to those existent in the far north on the border of the regions of perpetual snow. Finally this tundra region moved south, and the glacier itself came on. Probably neither the tundra zone bordering the glacier nor the coniferous forest zone beyond it were very wide when the glacier reached its maximum extension, for it was melting along its front, so the climate there could not have been very rigorous. The deciduous forest probably covered much of the southeastern portion of the continent and the arid plains and short grass regions much of the southwestern portions as now.

When the last glacial period was passing off and the great ice sheet was beating a slow retreat, the land, with topography much changed, was open to plant and animal occupation. The great tundras, the areas of stnnted trees, and the coniferous forests largely followed the glacier northward, leaving a few scattered remnants here and there. The climate of our region again became congenial to the deciduous forests, the prairie plants, and their accompanying animals.

Whence then came the plant and animal immigrants that replenished our barren region? Briefly stated, the facts are these. Certain elements of our present fauna and flora are relics of the tundras and the coniferous forests. In addition, the sterile land uncovered by the retreating glacier was gradually repopulated by immigrants from at least three centers, one an arid region in the southwest with whose fauna and flora ours has many affinities. A second center was in the southeast; from it, for example, have come most of our deciduous forest trees and our river clams. The third region from which ours has received contributions is the Atlantic Coast plain. Many animals and plants of the shores of the Great Lakes are identical with those of the eastern seacoast. And finally there is a very perplexing factor in that the only close relatives of certain of our plants and animals to be found anywhere in the world are along the eastern coast of Asia.

There are no remnants of the tundra formation in the immediate vicinity of Chicago, for such exist in eastern North America only in isolated patches on the mountain tops. Such are found in the Great Lakes region on the high hills of northern Wisconsin and Michigan. As examples of such forms may be mentioned the dwarf grass, *Agropyron biflorum*, the herbaceous willow, *Salix herbacea*, a very low form with an underground stem that lies in the wet mosses, *Rhododendron lapponicum*, *Arctostaphylos alpina*, some dwarf blueberries, *Vaccinum oliginosum* and *V. caespitosum*, mosses and lichens such as the *Cladonia rangiferina*.

There are, in the pine association of the Dunes, as already noted, extensive areas with a distinct boreal character. Here flourish *Pinus strobus*, *P. Banksiana*, together with the arbor vita, low and spreading junipers, such boreal shrubs as prince's pine, shinleaf, arbutus, northern herbs like star flower, false lily-of-the-valley, etc. There are scattered remnants of this coniferous society on rocky hills elsewhere, particularly on their dry crests and cold northern slopes. Associated at times with these plants in the Dunes, but elsewhere in our region quite isolated, is another subarctic formation, the sphagnum-tamarack bog society. This and the pine association, found in our region as more or less isolated islands in the midst of the prevalent oak-hickory society, are, farther north, the prevalent thing. The sphagnum bogs cover wide areas and have their maximum development in a region extending from north of the Gulf of St. Lawrence to northern New England in the East, thence west, spreading from mid–Lake Michigan shores to Hudson Bay and then northwest into Saskatchewan. There can be no doubt that this bog society like the pine association invaded our region in advance of the glacier and followed it back in its retreat, leaving the isolated patches in favorable localities to continue to the present, defying the encroachments of the plants and animals that later came to occupy most of the region. There is therefore no gradual transition from the sphagnum-tamarack bog society to the surrounding societies, but an abrupt break between the two, for this northern invader is surrounded by still later arrivals with which it has no genetic continuity. In the north it leads to the coniferous forest, but here the coniferous forest itself is at best struggling to maintain a none too secure footing. The coniferous forest farther north leads on to the hardwood climax forest, so that the transition from the pine association here to the black oak association is a relationship that is not strained. There seems to be some evidence, as at Cedar Lake, that the tamarack bog does still develop in this region. Young tamaracks are appearing in the sphagnum bog there and are pushing farther out into it.

How these northern elements came into our fauna and flora is quite evident. The glacier forced them south and the rising temperature in the south as the glacier retreated forced them to migrate north again or suffer extinction, except as relics survive in limited favorable localities. But what has forced the invasion into our region, since the glacier left it largely bare, of forms from the deciduous forest center in the southeastern part of the continent, the prairie and desert regions of the Southwest, or the Atlantic seaboard?

The driving power back of these movements is the urge of rapidly multiplying life. Each species tends to fill its habitat full to overflowing. So prolific are living things that the pressure to move out into adjacent territory is only checked by impassable barriers that raise the swelling tide until some outlet is found or multiplication is offset by the high mortality of keen competition. So quiet and unobtrusive is the life of the ordinary plant and animal that we humans find it difficult to realize how keen is the struggle for existence or with what celerity any new territory is occupied. There is no roar of hostile guns along the battle-line of opposing animal and plant interests, no press dispatches tell of starving thousands, no blare of trumpets or floating banners mark the progress of quiet invasion. But there is, nevertheless, tremendous activity. Reproduction is at a geometrical rate; that is, a pair does not give rise to another pair merely, but to a litter, a swarm, a horde. A single female codfish lays five million eggs at one spawning. A pair of potato beetles would produce in one season a progeny of sixty million, if all their offspring and their offspring, too, lived unmolested. "The descendants of a common housefly would in the same time—six generations of about three weeks each—occupy a space of something like a quarter of a million cubic feet, allowing two hundred thousand flies to a cubic foot. An oyster may have sixty million eggs and the average American yield is sixteen millions. If all the progeny of one oyster survived and multiplied, and so on until there were great-great-grandchildren, these would number sixty-six with thirty-three noughts after it, and the heap of shells would be eight times the size of the earth! Of course none of these things happen because of the checks imposed by the struggle for existence. Yet, every now and then, as man knows to his cost, a removal or diminution of the natural checks allows the potential productivity to assert itself for a short time or within a limited area. The river of life sometimes does overflow its banks, as it always *tends* to do, and the resulting flood is called a plague" (Thomson, *The Wonder of Life*).

Begin with a single dandelion plant bearing a single blossom cluster in the year—a slander on the enterprising dandelion—that gives rise to a hundred seeds. Let these find lodgment and next year produce plants that each grow a single blossom cluster that produces one hundred seeds, and so on. It will be a matter of less than ten years before there are enough dandelion plants to cover every foot of land upon the face of the earth. Or consider the coyote that brings into being a litter of eight or nine pups at a time. Suppose these are half male and half female and require two years to reach sufficient maturity to breed. Let the breeding life be only five years, and if nothing interfered with the multiplication of a single pair and that of their offspring inside of half a century there would be a coyote for every square foot of earth. The rancher who has tried to exterminate his coyote neighbors, or the householder who tries to keep his lawn free from dandelions, knows that the possibilities are not overdrawn.

As a result of such astounding fertility, usually more or less held in check by enemies that prey upon the offspring, there is every now and then an overflow of a species from its habitat into the surrounding territory, where if conditions are favorable it permanently establishes itself. The Rocky Mountain locusts have repeatedly appeared in great hordes in the plains states near the mountains, a devastating army that comes in clouds, darkening the sun, that leaves cornfields as barren wastes within a few hours after alighting upon them, plagues of locusts that have inflicted millions of dollars of damage on crops covering wide areas. The Lapland leming is a small rodent which every ten or fifteen years moves out from its home through surrounding regions in vast numbers, devouring every green thing and usually being devoured by hawks, owls, foxes, and other species of predatory animals that follow in its wake in numbers. In the *Farmers' Bulletin No. 352*, United States Department of Agriculture, is described a plague of mice in the Humboldt Valley, Nevada, from which a few sentences are quoted.

Extensive ravages first occurred above and about Lovelocks. In May, 1907, fields on the Rogers ranch, 5 miles below Lovelocks, were invaded from lands farther up the valley, the progress of the mice being plainly marked, as the fields above the Rogers ranch suffered first. The movement of this great body of mice, it should be noted, was a gradual, scattering progression, first by a few and later by increasing numbers, until the greater part had moved to fresh fields. . . . . By October, 1907, a large part of the cultivated lands in this district had been overrun by vast numbers of mice. . . . . The height of the abundance was reached in November, when it was estimated that on many large ranches there were 8,000 to 12,000 mice to each acre. The fields were riddled by their holes, which were scarcely a step apart, and over large areas averaged 150 to 175 to the square rod. Ditch embankments were honeycombed, and the scene was one of desolation. . . . . By November they had destroyed so large a percentage of the plants that many fields were plowed up as hopelessly ruined. . . . . By January, 1908, in fields where the mice had existed by thousands the previous summer and fall, comparatively few, possibly 200 to 500 to each acre, remained. The border of the destroyed district was about 6 miles below Lovelocks, and the mice were gradually moving down the valley.

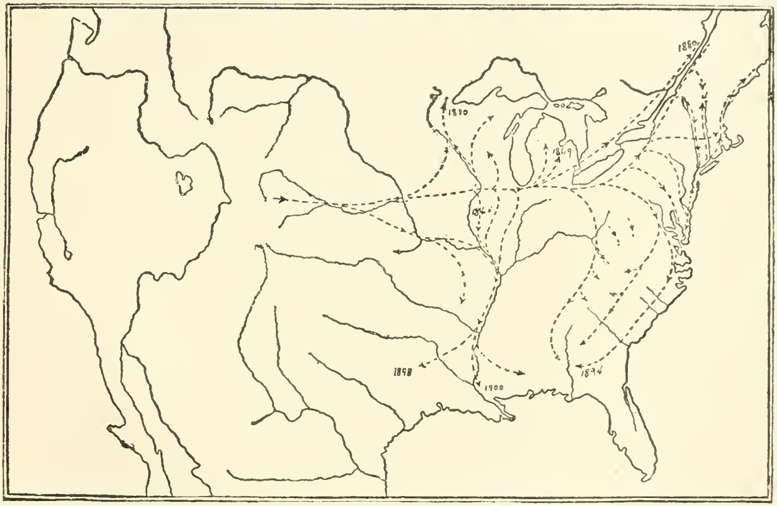


FIG. 449.—Map of potato beetle invasion, with dates of arrival at some localities. After Tower.

The exact data regarding such invasions of adjacent territory by animals and plants are, as a rule, only available when the invading forms affect man's crops or his domestic animals. When about the middle of the last century settlers pushing westward brought the fields of cultivated potatoes to the edge of the habitat of the Colorado potato beetle, there feeding on wild species of the potato family, the eastward movement of this animal began. The progress of its invasion and the routes followed can be seen on the accompanying map (Fig. 449). Similarly the cotton-boll weevil, which came out of Mexico to invade the United States, is rapidly spreading all over the South where cotton is a crop. Its advance is shown in the accompanying map (Fig. 450). Jimson weed (a shortening of the original name, Jamestown weed) was introduced from the Old World into this country at Jamestown in colonial days, from whence it has spread all over the Eastern United States. Russian thistle, introduced into this country by immigrants in wheat seed planted in North Dakota in 1873, has since then spread pretty much all over this country and much of Canada east of the Rockies.

This insurgency of living things, impelling them to seek new fields to conquer, soon repopulated, from the three centers named, the territory laid waste by the glacier. Southeastern United States seems to be the distribution center from which have come most of our deciduous forest trees, the river clams, such snails as the *Pleuroceridae* and *Viviparidae*, most crayfish, and a large share of our fish. Undoubtedly many other forms have also come from this same center concerning whose movements we have little or no data. This southeastern center is particularly rich in species and varieties of the forms mentioned. They there attain their maximum size. From this center the connecting rivers and their valleys afford easy highways of invasion. All of which are good criteria for determining centers of immigration. A map of North America on which there is drawn in outline the present range of a number of our important trees shows at a glance that this southeastern area is a center for all (Fig. 451). There are omitted from this the evergreens and such deciduous trees as evidently belong to the northern forest.

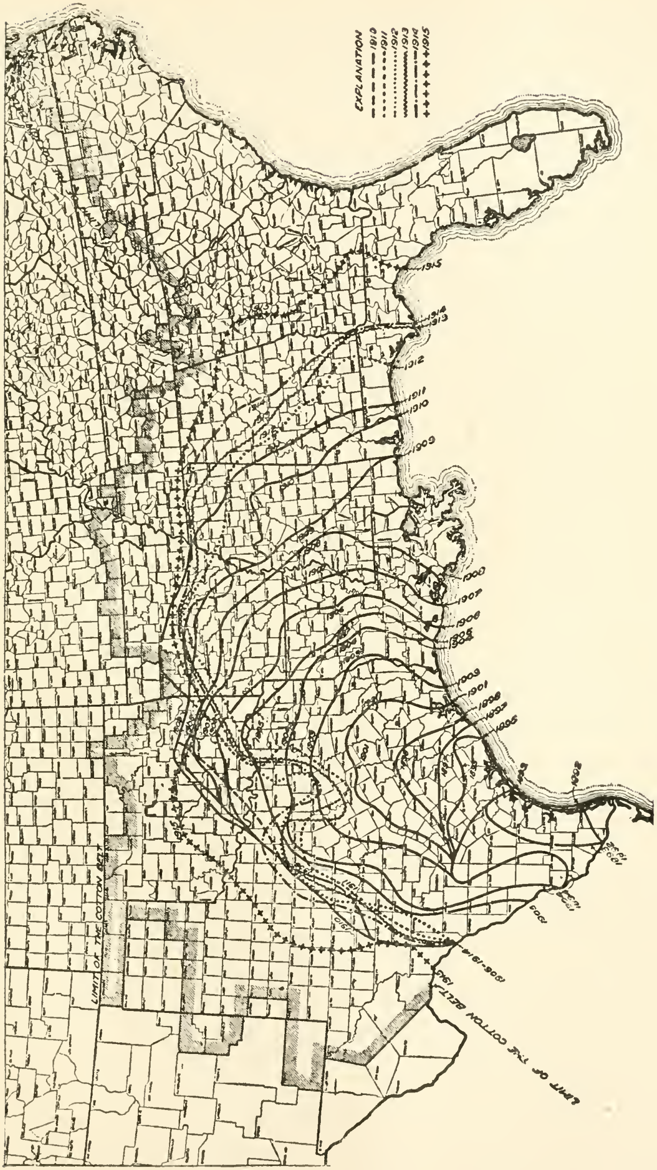

EXPLANATION
1910
1911
1912
1913
1914
1915
LIMIT OF THE COTTON BELT
LIMIT OF THE COTTON BELT
1915
1914
1913
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1901
1898
1897
1895
1902
1906-1910-1912
1915

FIG. 450.—Map showing invasion of the cotton-boll weevil

There are more species of fresh-water clams in this southeastern area, with Chattanooga as its approximate center, than in all the rest of the world. The number of species decrease as you go farther and farther away from this center. Thus, while Maine has only 10 species of *Unionidae*, Michigan, much nearer along the migration route, has 61, Illinois 88, and Alabama 256. Of the *Pleuroceridae* Maine has none, Michigan 10, Illinois 28, while Alabama has 302. Bryant Walker (*Distribution of the Unionidae in Michigan*, Michigan Academy of Science, 1898) considers that the Michigan *Unionidae* are almost entirely Mississippian, only two species, *Anadonta fragilis* and *Unio complanatus* having come from the east. These clams must

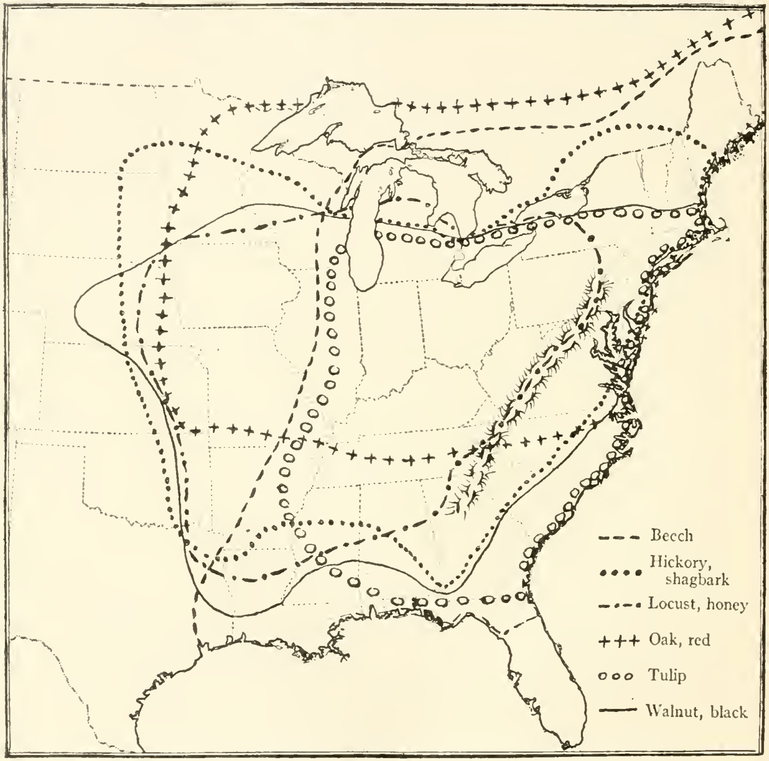


FIG. 451.—Distribution of certain typical deciduous trees

have reached Michigan while Lake Chicago and its successors drained by way of the Illinois and the Wabash, since now all the streams of Michigan are part of the St. Lawrence drainage system. That some of the more hardy of the clams did follow the glacial retreat closely is evidenced by the fact that their shells are found in undisturbed beaches of the post-glacial lakes.

Of the 150 species of fresh-water fishes found in Illinois that are native to the state "there are 58 species of the east Gulf and Florida district" (Forbes and Richardson, *The Fishes of Illinois*, "Natural History Survey of Illinois"). From the west Gulf and Rio Grande region there are forty-seven species of fish (same authority). From this same southwestern center come such animals as our pocket gopher, rattlesnake, six-lined lizard; and such plants as the dune cactus, *Andropogon scoparius*, *A. furcatus*, *Panicum praecocius*, *Schedonnardus paniculatus*, *Cyperus aristatus*, *C. acuminatus*, *Eleocharis tenuis*, *Carex tribuloides*, *Asclepias tuberosa*, *Silphium terebinthinaceum*, *Rudbeckia hirta*, all plants that find congenial habitat in the dry sandy areas or the dry prairies.

From the Atlantic coastal plain region our fauna and flora have received many contributions. It will be recalled that during the retreat of the glacier our Great Lakes region was in much more direct communication with the Atlantic seaboard than it is at present (Fig. 52). There are fifty-three of the fish of Illinois that have come from Quebec and the New England region. As already noted, some of our clams come from this eastern center, possibly originally emanating from the southeastern center, but if so migrating to our region by way of the coastal plain. A large number of the plants found along the shores of the Great Lakes seem to have come from this source. A few may be mentioned, such as *Panicum verrucosum*, *P. oligosanthes*, *Aristida tuberculosa*, *Ammophila arenaria* (marram grass), *Eleocharis melanocarpa*, *Psilocarya scirpoides*, *Fuirena squarrosa*, *Cakile edentulata* (sea rocket), *Euphorbia polygonifolia* (seaside spurge), *Xanthium echinatum* (cocklebur).

Finally a great many of our plants and animals are common to Northern Eurasia and Northern North America, while some of ours have their nearest relatives along the eastern edge of Asia. Our common bluebird (*Sialia sialis*) has an isolated close relative (*Sialia coelicolor*) in Eastern Asia. Our spoonbill and carp sucker, the former a peculiar mud-eating fish, have each a near relative in China. Our crayfishes are more nearly related to those of Eastern Asia than to the species of our own Pacific Coast or of Eastern Europe. Our dragon flies, *Hagenius* and *Boyeria*, have close relatives in Eastern Asia. The tulip tree, sweet gum, and sour gum all belong to genera found nowhere else in the world except Eastern North America and Eastern Asia.

Confining our attention to the ferns, horsetails, and club mosses, the following are common to Europe and North America, including our Great Lakes region: *Polypodium vulgare, Aspidium cristatum, A. spinulosum, Osmunda regalis, Equisetum fluviatile, and E. hyemale.* In Asia and our region are found *Cryptogramma Stellari, Asplenium acrostichoides, Onoclea sensibilis, Osmunda Claytoniana.* While common to Eurasia and North America and found in our region are such forms as *Phegopteris polypodioides, P. Dryopteris, Onoclea Struthiopteris, Osmunda cinnamomea, Ophioglossum vulgatum, Botrychium ternatum, Equisetum pratense, E. sylvaticum, E. variegatum, Lycopodium annotinum,* and *L. complanatum.*

It must be evident, then, that much of the fauna and flora in the northern part of the world before the glacial advance began was common to Eurasia and North America, and that this life common to the two continents included many forms now found pretty well south. Possibly, too, since the glacier retreated there has been land continuity between Asia and North America, and an invasion route has led from Eastern North America through the Northwest to Asia with movements of plants and animals proceeding in both directions. Much additional evidence must be accumulated before this last point can be satisfactorily settled.

AN OUTLINE OF SOME OF THE IMPORTANT PLANT AND ANIMAL ASSOCIATIONS

Associations Changing Successively as Land Construction Goes on

The Filling Lake in the Dune Area

1. The beach association	Predatory beetle association
2. Fore-dune association	
3. Cottonwood association	Digger-wasp association
Transition zone	Large tiger beetle association
4. Pine association	*Cicindela hirticollis* association
5. Black oak association	Ant-lion association
6. Mixed oak association	Tree frog association
Oak-hickory association	Green tiger association
Beech-maple association	Wood frog association

(For the last two see p. 306)

The filling pond or small lake leads on to

a) the wet prairie and finally to the dry prairie

b) the swamp with white ash-elm association, and finally to the climax forest

c) the sphagnum bog and tamarack swamp. The early stages of these are practically identical, namely (7 is usually wanting in *c*)

7. Bare bottom association	*Lampsilis luteolus* association
8. Chara association	Bloodworm association
9. *Utricularia Myriophyllum* association	*Ischnura verticalis* association

They then differentiate as follows:

(*a*)

10. Water lily association	Painted turtle association
11. Bulrush association	Marsh wren association
12. *Carex-Scirpus* association	Green flatworm association
13. Swamp grass association	Bobolink association

Andropogon furcatus, meadow lark association (see p. 306)

(*b*)

10. Water lily association	Painted turtle association
11. Bulrush association	Marsh wren association
14. Cat-tail association	Redwing association
15. Buttonbush-prickly ash association	*Succinea* association

16. Ash-elm association	Green heron association

In steep-sided ponds this last may be replaced by the

17. Swamp white oak association, which gives place to the oak forest

(*c*)

18. Floating sedge association	Northern locust association
19. Sphagnum-Cassandra association	
20. Tamarack association	

21. The flood-plain or elm–soft maple association

This is subdivided into

22. The bare river margin	Spotted sandpiper association
23. Ragweed-sunflower association	Plant bug association
24. Willow association	*Cecropia* association
25. Young ash-elm-maple association	Yellow warbler association
26. Mature elm-maple association	Tanager association

The flood-plain association is stratified like the climax forest (which see) and the several strata may be named as in the climax forest though the constituent plants and animals will be somewhat dissimilar.

Associations that Are Relatively Permanent, the Climax of Constructive Processes, Known as Climax Associations

They are:

27. The prairie or *Andropogon furcatus* association	Meadow lark association
28. The oak-hickory association	Green tiger association
29. The beech-maple association	Wood frog association

Each of these is subdivided. In addition to the prairie grasses other plants are conspicuous, and several types of prairie may be distinguished in addition to the wet prairie (bobolink) and the *Andropogon furcatus* (meadow lark) prairie.

30. High prairie or *Silphium* association	Jumping spider association
31. Very dry or *Eryngium* association	Leaf hopper association
32. Thin soil, rock bottom, prairie clover association	

The oak-hickory and beech-maple forests each have a

33. Forest margin or *Crategus* association	Brown thrasher association

Each is divisible into successive strata, much alike in the two except for variations in the abundance of the constituent forms.

34. The forest crown association	Tree cricket association

35.	The tall shrub association	*Epeira* association
36.	The low shrub association	Wood nymph association
37.	The ground association	Snail association
	This in turn may be subdivided into	
38.	Litter association	Thousand leg association
39.	Rotting log association	Horned *Passalus* association
40.	Fungus association	Fungus beetle association
41.	Subterranean association	Cicada nymph association

ASSOCIATIONS CHANGING SUCCESSIVELY AS LAND DESTRUCTION OCCURS

42.	The shore clay bluff association	*Cicindela limbalis* association
43.	River bluff association	Kingfisher association
44.	Clay ravine association	Spearhead dragon-fly association
45.	Rock ravine association	Phoebe association
46.	The rock hill association	

THE RIVER ASSOCIATIONS

Communities of the Intermittent Streams

47.	Intermittent rapids association	Black fly association
48.	Intermittent pool association	*Cambarus* association
49.	Permanent pool association	Horned dace association

Communities of Permanent Streams

50.	*a*) The spring-fed brook water cress association	*Planarian* association
	b) The usual alkaline streams associations as follows:	
51.	The very rapid water (lotic) society	*Hydropsyche* association
	This is subdivided into	
52.	The brook rapids or	Rainbow darter association
53.	The creek rapids or	Fantail darter association
54.	The river rapids or	Banded darter association
55.	The moderately rapid, sandy bottom association	*Campeloma* association
	Which may be divided as above	
56.	The sluggish water (Limnetic) surface society	*Daphnia-Cypris* association
57.	The sluggish water (Limnetic) bottom society	The clam association
58.	The estuary association subdivided much as is the pond society	
59.	(*c*) The acid stream association	

BOOK LIST

The following list of books includes some of the most useful in determining animals and plants in the area studied, together with a few titles that will serve to introduce the reader to a more extended study of the subject. Additional bibliographies will be found in these latter.

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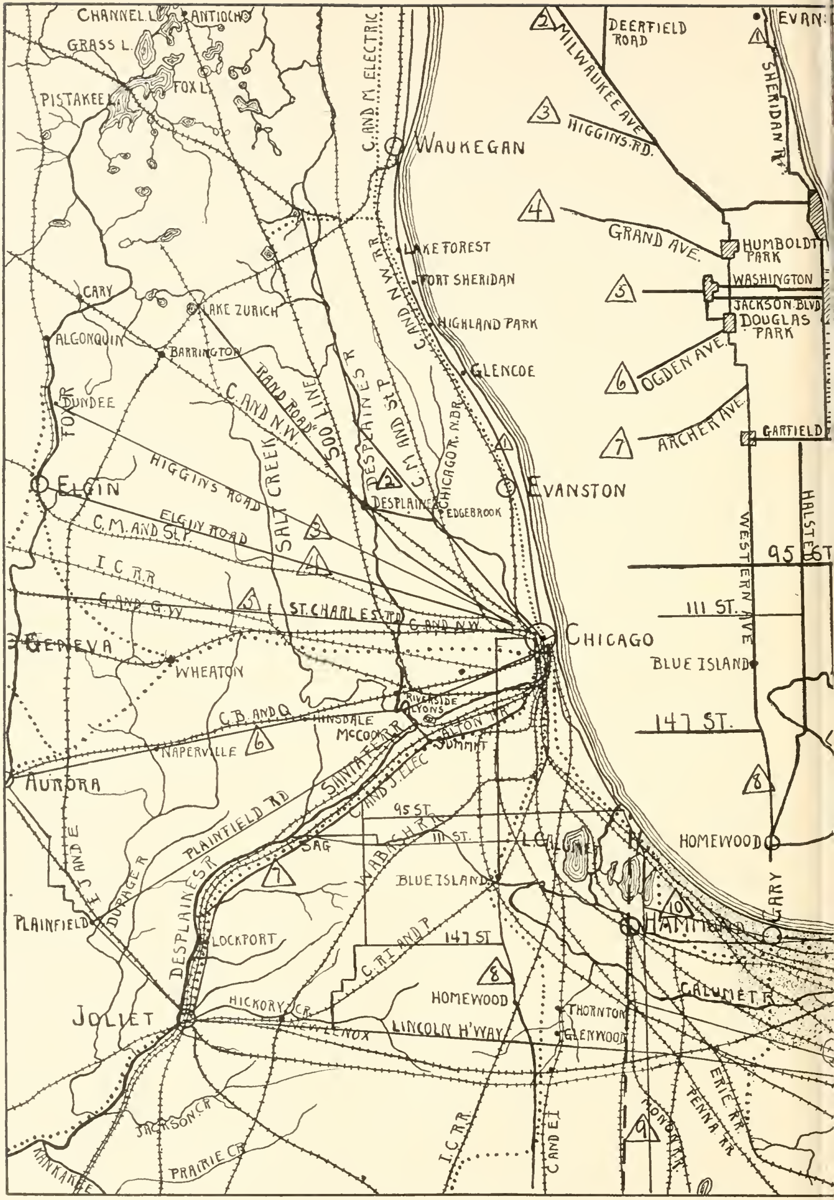
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ANTIOCH
GRASS L.
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FOX L.
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DEERFIELD ROAD
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GRAND AVE.
HUMBOLDT PARK
5
WASHINGTON
JACKSON BLVD.
DOUGLAS PARK
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OGDEN AVE.
7
ARCHER AVE.
GARFIELD
LAKE FOREST
FORT SHERIDAN
HIGHLAND PARK
GLENCOE
C. AND N.W. R.R.
CARY
ALGONQUIN
LAKE ZURICH
BARRINGTON
RAND ROAD
C. AND N.W.
SOO LINE
DESPLAINES R.
C.M. AND St. P.
CHICAGO R. N. BR.
DUNDEE
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LOCKPORT
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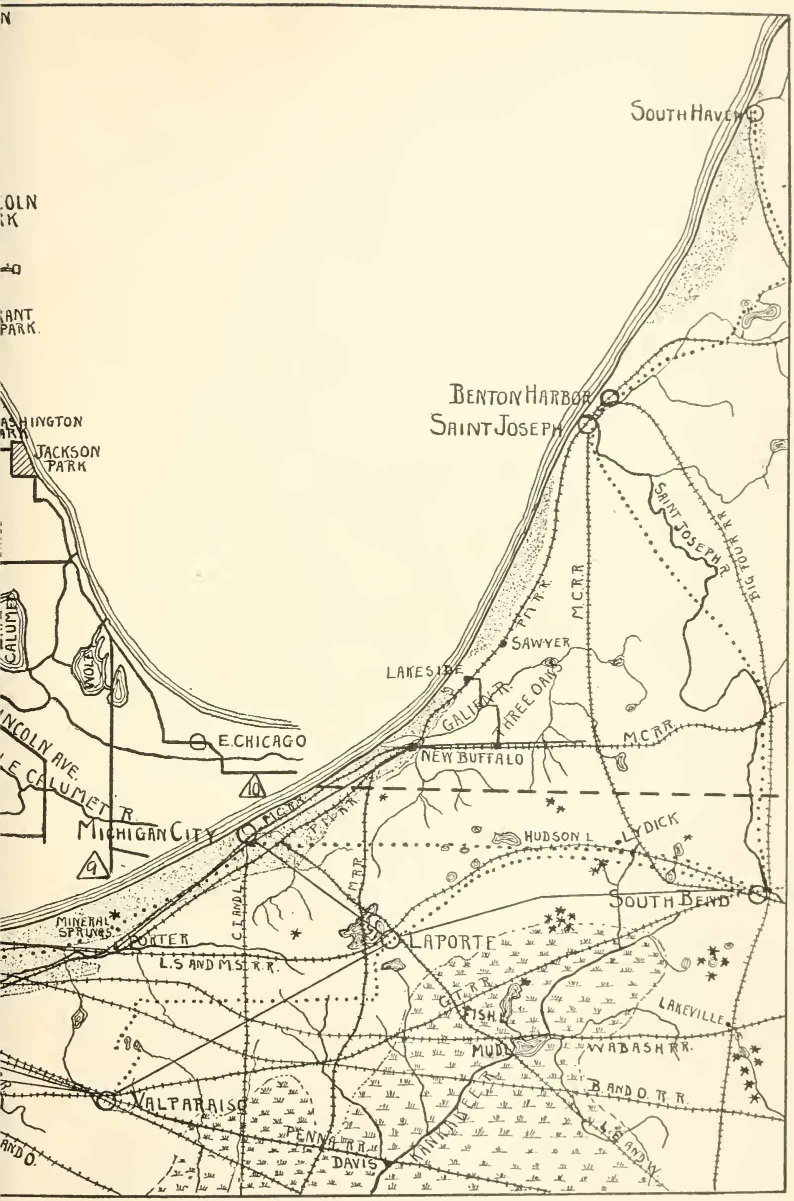
NEW LENOX
LINCOLN H'WAY
THORNTON
GLENWOOD
ERIE R.R.
PENNA. R.R.
MONON R.R.
9
JACKSON CR.
I.C. R.R.
C. AND E. I.
PRAIRIE CR.
KANKAKEE

Fig. 452.—Map of Region about South End of Lake Michigan, and an In

The Dune areas are dotted in. This territory really occupies a larger area about Lake Calumet and to the purposes of this book. *This sign indicates the Tamarack bog. Electric lines are thus shown........

A few of the main automobile roads out of Chicago are shown by a single line————. They are map correspond to the numbers on the inset map, which indicates how the city streets connect up with the a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SOUTH HAVEN
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K
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PARK.
BENTON HARBOR
SAINT JOSEPH
ASHINGTON
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PARK
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BIG FOUR R.R.
M.C.R.R.
P.M.R.R.
SAWYER
LAKESIDE
GALIEN R.
THREE OAKS
CALUMET
WOLF
E.CHICAGO
NEW BUFFALO
M.C.R.R.
INCOLN AVE.
LE CALUMET R.
10
MICHIGAN CITY
M.C.R.R.
P.M.R.R.
HUDSON L.
LYDICK
9
M.R.R.
SOUTH BEND
MINERAL SPRINGS
PORTER
C.I.AND L.
LAPORTE
L.S.AND M.S.R.R.
G.T.R.R.
FISH L.
LAKEVILLE
MUD L.
WABASH R.R.
KANKAKEE R.
B.AND O.R.R.
VALPARAISO
R.
PENNA R.R.
DAVIS
L.E.AND W.
AND O.

Showing the Main Automobile Routes Out of the City of Chicago

south and east, but manufacturing plants and railroads have so altered it that it is nearly valueless for
er signs are conventional.
drawn to show the route in detail, but merely the general direction. Numbers in triangles on the large
mobile roads.

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